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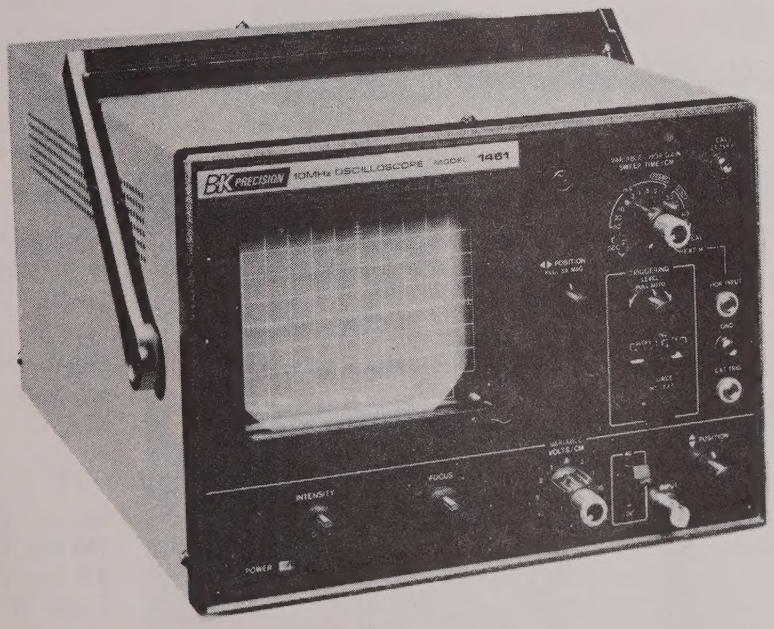
B&K 1461

SERVICE MANUAL

B+K PRECISION Model 1461

10 MHz, TRIGGERED SWEEP

OSCILLOSCOPE



MODEL 1461

B+K PRECISION

Product of DYNASCAN CORPORATION
6460 W. Cortland St., Chicago, Illinois 60635

OUTLINES

MODEL **M-1461** is a trigger-sweep type oscilloscope equipped with a 130 mm cathode ray tube (CRT) and integrated circuits. Due to its wide frequency range from DC to 10 MHz, sweeping speed from 1 μs/div to 0.5 s/div, and provision of TV synchronizing separator circuit, it is capable of observation and measurement of TV video signals and various waveforms in general electronic devices and equipment.

SPECIFICATIONS

Type of Cathode Ray Tube	C529P31B or 130BEB31
Acceleration Voltage	2 kV

VERTICAL AXIS

Sensitivity	10 mV/div ~ 20V/div ±5%
Attenuator	10 mV/div ~ 20 V/div, 1-2-5 step (1 div = 1 cm) Precisely adjustable in all ranges. Sensitivity error between ranges is ±5%.
Input Impedance	1 MΩ ±5%
Input Capacitance	22 pF ±3 pF
Frequency Response	DC: DC ~ 10 MHz (less than −3 dB) AC: 2 Hz ~ 10 MHz (less than −3 dB)
Rising Time	Less than 35 nsec.
Overshoot	Less than 3% (at 100 kHz square wave)
Maximum Input Voltage	600 V p-p or 300 V (DC + AC peak)

SWEEP CIRCUIT

Sweep System	Triggering sweep and auto sweep (free-running sweep at no-signal time)
Sweep Time	1 μs/div ~ 0.5 s/div ±5% and EXT H, 1-2-5 step Fine adjustment in all 18 ranges
Magnifier	5 times ±10% (PULL x 5 MAG)
Linearity	Less than 3% (5 μs/div ~ 0.5 s/div) Less than 5% (1 μs/div ~ 2 μs/div)

SYNCHRONIZATION

Sync Input	
INT	Vertical input signal
EXT	EXT TRIG input signal
Sync Section	
NOR	Positive and negative
TV	Positive and negative (TVH and TVV are automatically switched by SWEEP TIME/DIV)
TVH (TV-Line)	1 μs/div ~ 50 μs/div
TVV (TV-Field)	0.1 ms/div ~ 0.5 s/div
Sync Voltage	Amplitude on CRT screen, more than 1 div
Sync Frequency	EXT: more than 1V p-p INT: 20 Hz ~ 10 MHz EXT: DC ~ 10 MHz

HORIZONTAL AXIS

Operating Mode	EXT H mode is selected by SWEEP TIME/DIV
Sensitivity	150 mV/div (within ±20%) (HOR GAIN MAX)
Frequency Response	DC ~ 1 MHz (less than −3 dB)
Input Impedance	100 kΩ 35pF (less than)
Calibrating Voltage	1 V p-p ±5% (50/60 Hz square wave)

LUMINANCE MODULATION

Input Voltage	Less than 5 V p-p
Input Impedance	10 kΩ ±20%

POWER SOURCE

Power Supply Voltage	100/120/220/240V ±10%, 50/60 Hz
Power Consumption	20 W

DIMENSIONS AND WEIGHT

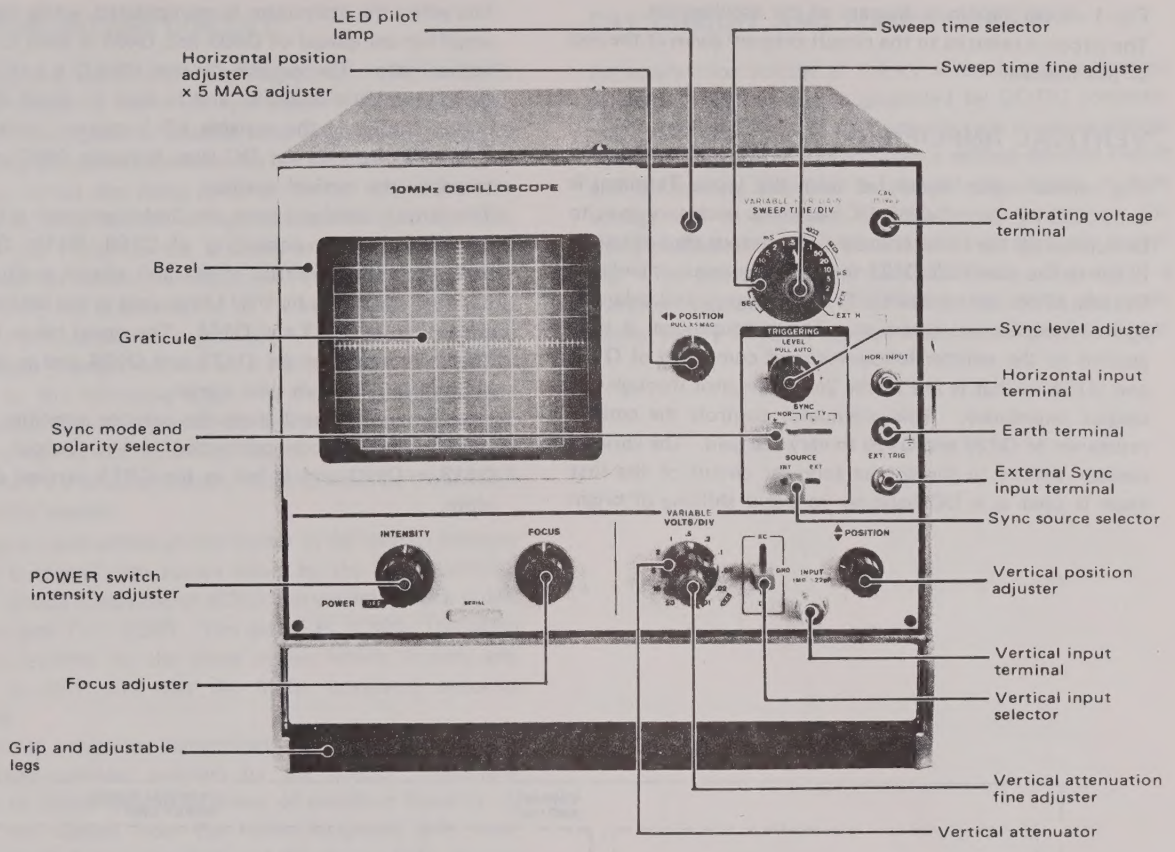
Width	260 mm (277 mm)
Height	190 mm (204 mm)
Depth	375 mm (433 mm) Figures in ( ) show maximum sizes.
Weight	8 kg

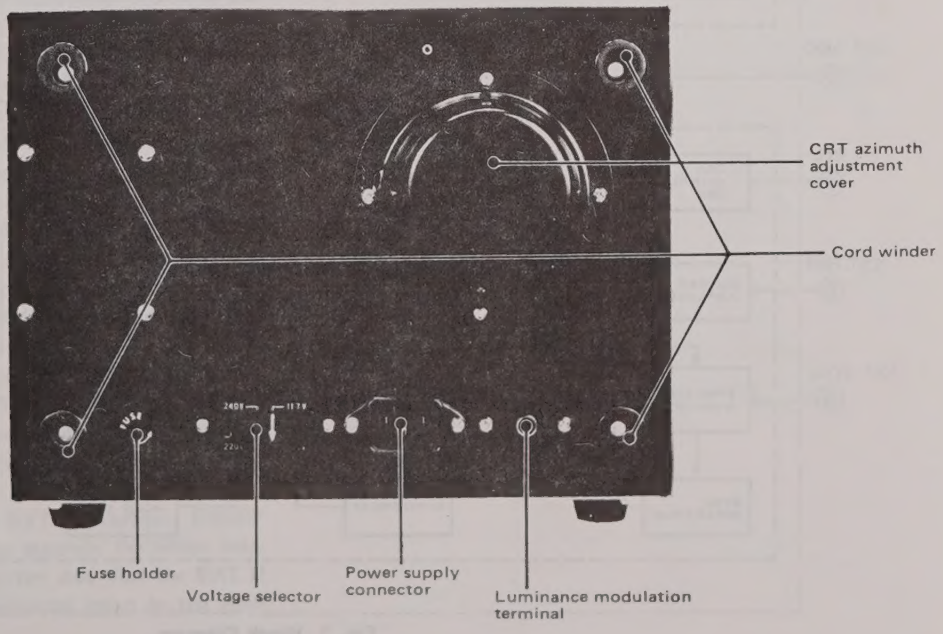
ACCESSORY

Probe

Model No.	PR-31
Attenuation:	Combination 10:1 and direct.
Input Impedances:	10:1 = 10 megohms, 18 pf. Direct = 1 megohm, 120 pf.
Connector:	BNC
Tip:	Spring loaded, hook-on tip.

EXTERNAL VIEW AND NAME OF PARTS





CIRCUIT DESCRIPTIONS

Fig. 1 shows the block diagram of the oscilloscope.
The circuit is referred to the circuit diagram given at the end of this manual.

VERTICAL AMPLIFIER

The vertical input signal fed from the Input Terminal is controlled by the AC-GND-DC switch as necessary so as to be applied to the 1st attenuator. The output thus obtained is fed to the dual FET Q121 through high input impedance. Because of the use of dual FET, DC voltage is well balanced against temperature variation. The output signal is then applied to the emitter follower circuit composed of Q123 and Q124 so that is fed to the 2nd attenuator through low output impedance. This attenuator controls the emitter resistance of Q125 and Q126 to vary the gain. The variable resistor VR111 in the source follower circuit of the first stage is used as a DC balancer to avoid shifting of bright line when the attenuator is manipulated, while the variable amplifier composed of Q403 and Q404 is used to vary the vertical gain. The variable resistor VR402 is a DC balancer for the variable amplifier and is used to avoid shifting of bright line when the variable VR is rotated, while VR112 is used to balance the DC level between Q403 and Q404 to adjust the vertical position.
The output obtained from the 2nd attenuator is fed to the cascode amplifier consisting of Q109, Q110, Q111 and Q112 to reduce mirror effect and obtain sufficient gain which is adjustable by VR113 inserted in the emitter circuit consisting of Q143 and Q144. The signal taken from this circuit is amplified by Q127 and Q128 and is led to the horizontal circuit as sync signal.
The output obtained from the cascode amplifier is amplified by the cascode connected vertical output amplifier Q113 ~ Q120 and is fed to the CRT's vertical deflecting plate.

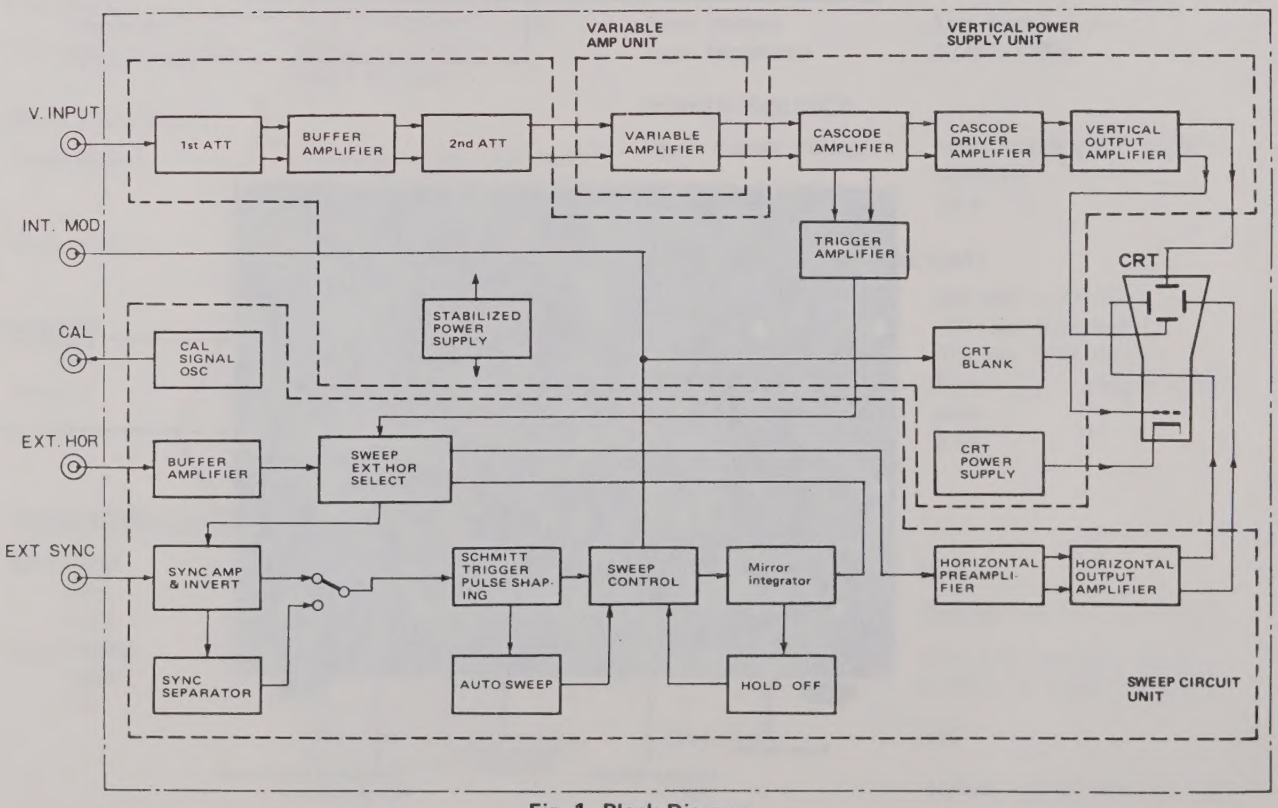


Fig. 1 Block Diagram.

CIRCUIT DESCRIPTIONS

SYNCHRONIZING CIRCUIT

The triggering signal, after selecting the type (INT or EXT) of sync voltage is fed to the sync amplifier. In this amplifier, the input point is selected according to the polarity of the SYNC switch to determine the starting point of synchronization, either the rising point or the falling point of the waveform; also, the DC voltage corresponding to the position of the TRIG LEVEL is added to the triggering signal to change the sweep starting point. With the SYNC switch set to TV±, the output is fed to TV sync separator circuit. In the TVH position, the peak point of pulse of horizontal sync signal is amplified and only the horizontal sync signal is fed to the following stage. In the TVV position, the integration circuit is connected and only the vertical sync signal is fed to the following stage. Changeover between TVH and TVV is automatically accomplished by the SWEEP TIME/DIV switch.

The signal passing through the buffer in the emitter follower circuit is shaped into square waves by the 2-gate Schmidt trigger circuit consisting of IC303 and becomes clock pulses for the gate F.F. IC301. The gate F.F. IC301. The gated F.F. is inverted by the clock pulses, which, in turn, sets Q307 to OFF and thus the Miller integrator becomes charged.

The miller integrator determines the sweep time by the C/R time constant selected by the SWEEP TIME/DIV switch to obtain saw-tooth waves of excellent linearity.

When the output from the Miller integrator fully rises, the hold-off F.F. is inverted and the sweep stops for the time determined by the hold-off time constant.

When the hold-off time passes, the next clock pulse is set in standby mode and thereby the sweep returns to the original status. When the TRIG AUTO switch is turned on, the Miller integrator also detects the presence of triggering signal fed from the Schmidt circuit to drive the AUTO circuit. With no triggering input, the output of AUTO circuit becomes low and, therefore, the gate F.F. starts automatic sweeping. With triggering input, the output of AUTO circuit becomes high and the gate F.F. synchronizes to clock pulses. The sweep time is adjustable with the variable resistor VR306 inserted in the time constant circuit of the Miller integrator, while the DC component in the Miller output is varied by VR305 to adjust the horizontal position.

The saw-tooth waves pass through SWEEP EXT H SELECT and are fed to the horizontal amplifier where the signal is amplified to the specified horizontal deflection voltage and is then directly fed to the horizontal deflecting plate of CRT.

With SWEEP TIME/DIV set to EXT H position, SWEEP EXT H SELECT is switched to separate the Miller integrator from the horizontal amplifier and thus the EXT H buffer output is applied as horizontal input to the horizontal amplifier.

CRT CIRCUIT AND POWER CIRCUIT

An acceleration voltage of 1.9 kV is required for operation of CRT. This voltage is generated by DC-DC converter and is stabilized through the feedback type constant voltage circuit. The CRT circuit includes a voltage doubler circuit and a blanking amplifier to prevent the change in high voltage due to increased luminance and to improve the rising characteristic of unblanking during high speed sweeping. The power circuit is fully stabilized. The use of a tracking regulator with IC OP amplifier keeps the main power supply constant against variations of power voltage.

MAINTENANCE

REMOVING THE CASE (Refer to Figs. 2, 3)

1. Remove the six screws from the top and side walls of the case, using a Phillips head screwdriver.

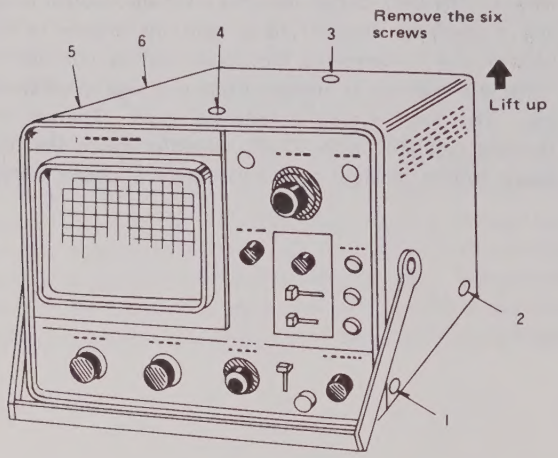


Fig. 2 Removing the Case

2. Hold the handle and lift up. The case is now ready for removal.
3. To remove the bottom plate, unscrew the six screws using a Phillips head screwdriver.

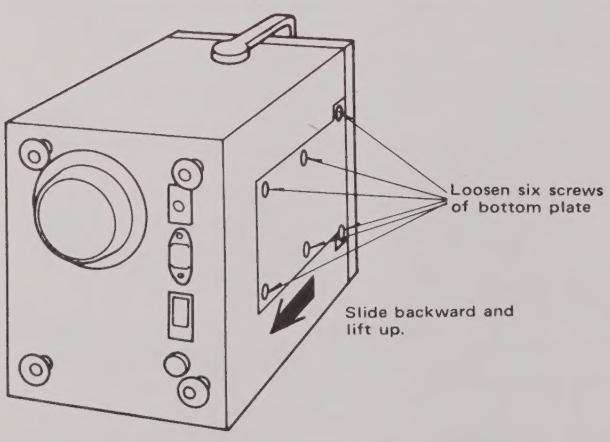


Fig. 3 Removal of Bottom Plate

Caution:
A high voltage (2000V) is present on the CRT socket and the lower printed circuit board. Before removing the case, be sure to turn off the power, and do not touch these parts with hand or a screwdriver even after the case has been removed.

AC VOLTAGE SELECTOR

The oscilloscope may be operated from 100V, 120V, 220V, 240V, putting the AC voltage selector in place of another.

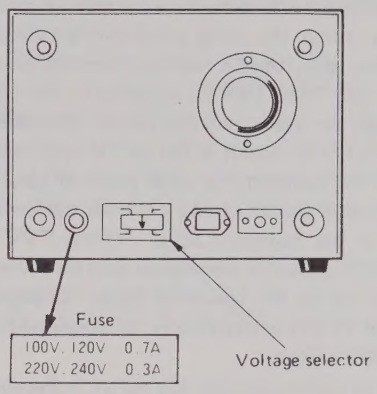


Fig. 4

ADJUSTMENT OF CRT BRIGHT LINE AZIMUTH (Refer to Fig. 5)

1. Loosen the two screws holding the azimuth adjustment cover to the rear panel.
2. Turn the CRT cover to align the bright line of CRT with the horizontal line of the scale. The CRT turns together with the cover.
3. Retighten the screws making sure that the bright line is in the horizontal position.

Note:
Do not remove the screws of the azimuth adjustment cover during adjustment.
The CRT shield mounting screws have no concern with the adjustment of bright line.

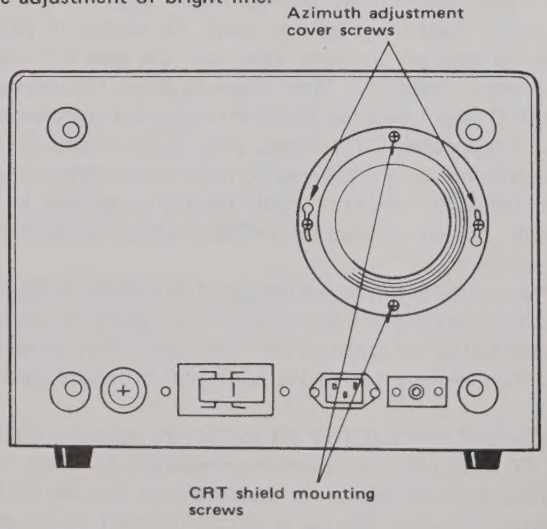
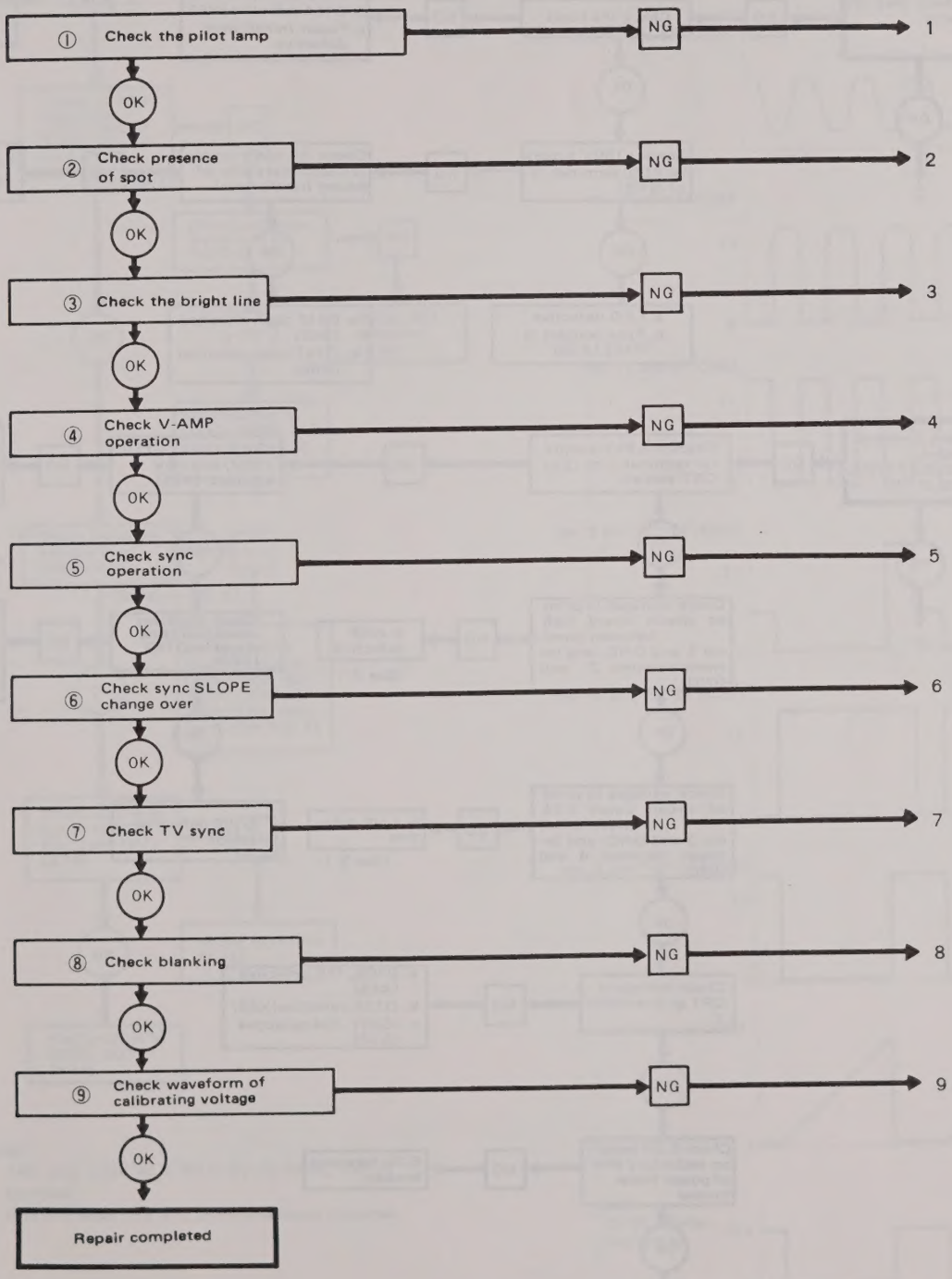


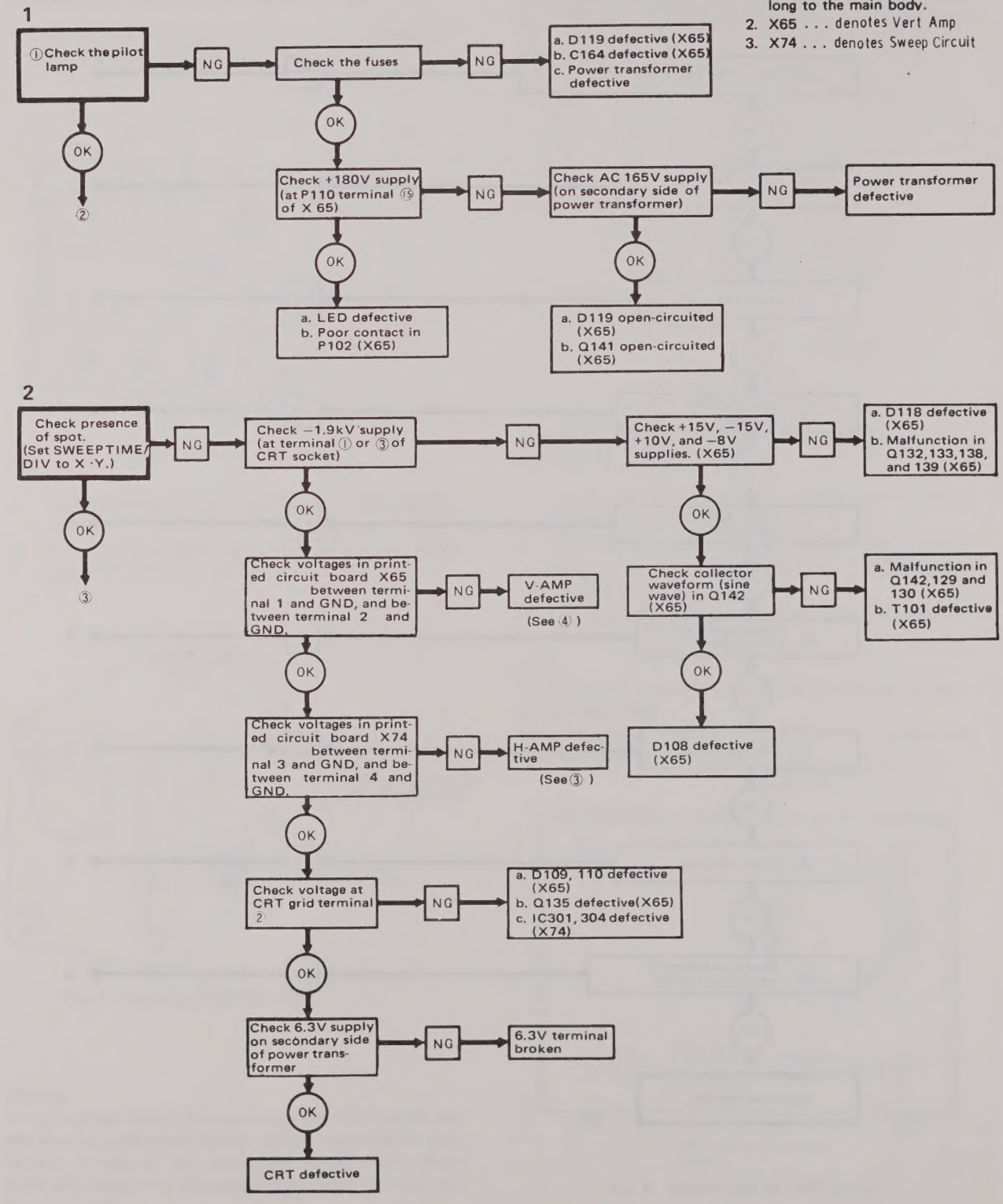
Fig. 5 Adjustment of CRT Bright Line Azimuth

TROUBLESHOOTING



TROUBLESHOOTING

Notes:
1. Parts without particular notes belong to the main body.
2. X65 . . . denotes Vert Amp
3. X74 . . . denotes Sweep Circuit



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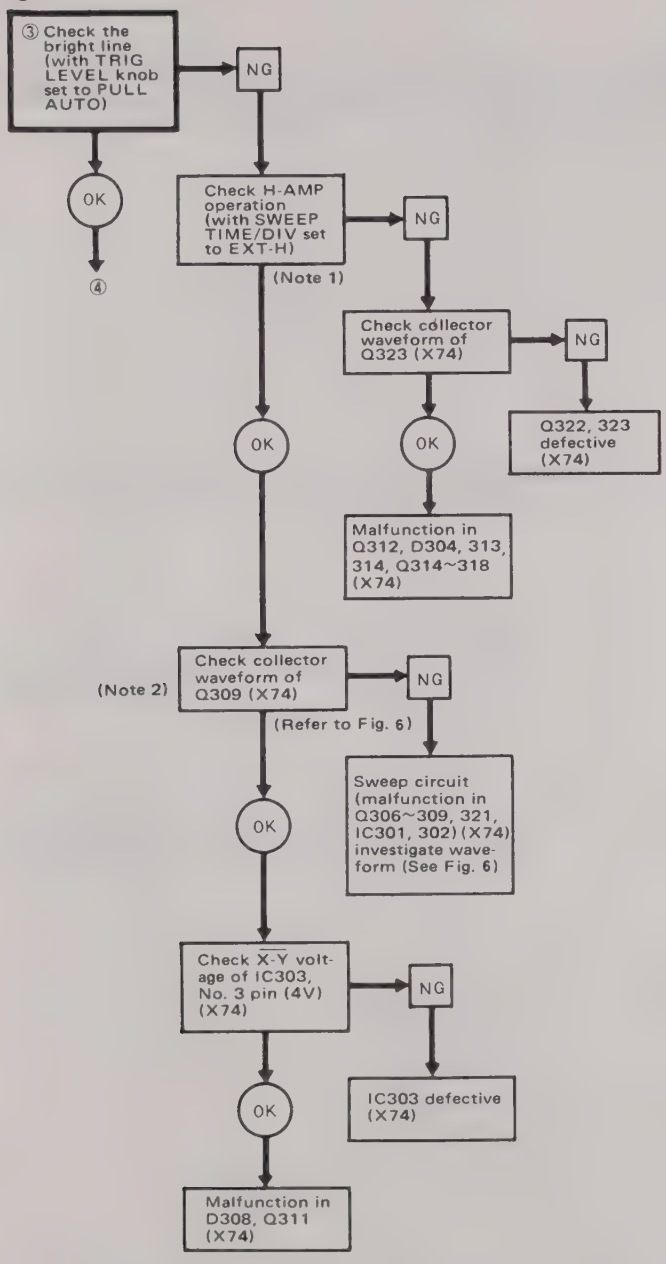
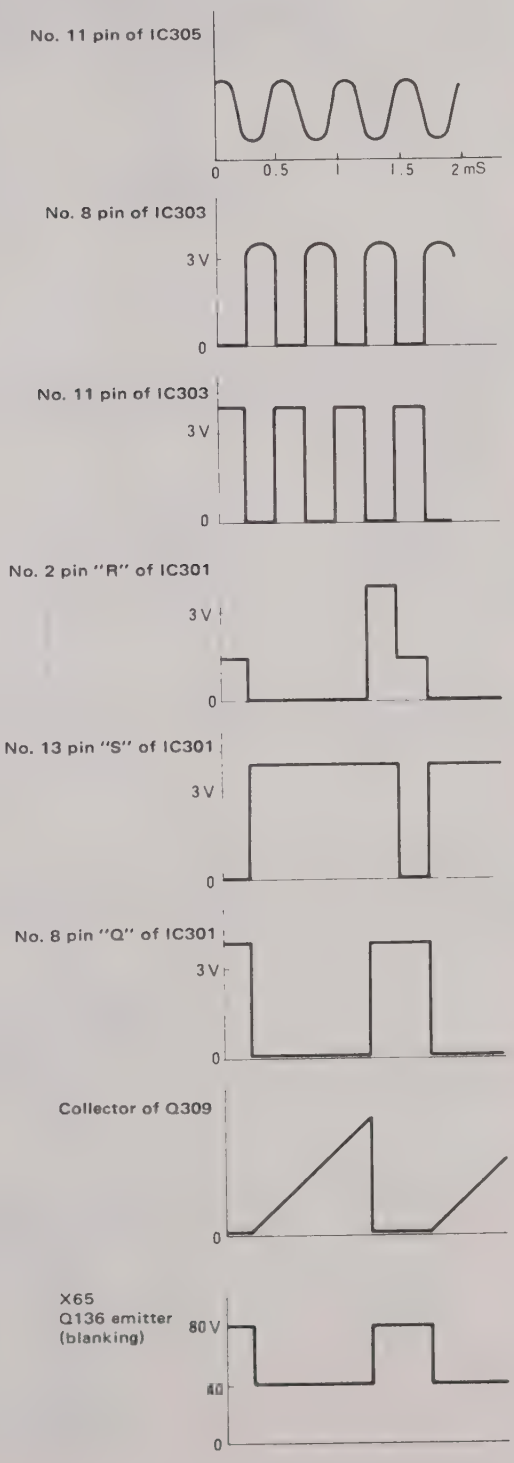

③ Check the bright line (with TRIG LEVEL knob set to PULL AUTO)
NG
OK
④
Check H-AMP operation (with SWEEP TIME/DIV set to EXT-H)
(Note 1)
NG
Check collector waveform of Q323 (X74)
NG
Q322, 323 defective (X74)
OK
OK
Malfunction in Q312, D304, 313, 314, Q314~318 (X74)
(Note 2)
Check collector waveform of Q309 (X74)
NG
(Refer to Fig. 6)
Sweep circuit (malfunction in Q306~309, 321, IC301, 302) (X74) investigate waveform (See Fig. 6)
OK
Check X-Y voltage of IC303, No. 3 pin (4V) (X74)
NG
IC303 defective (X74)
OK
Malfunction in D308, Q311 (X74)

Notes:

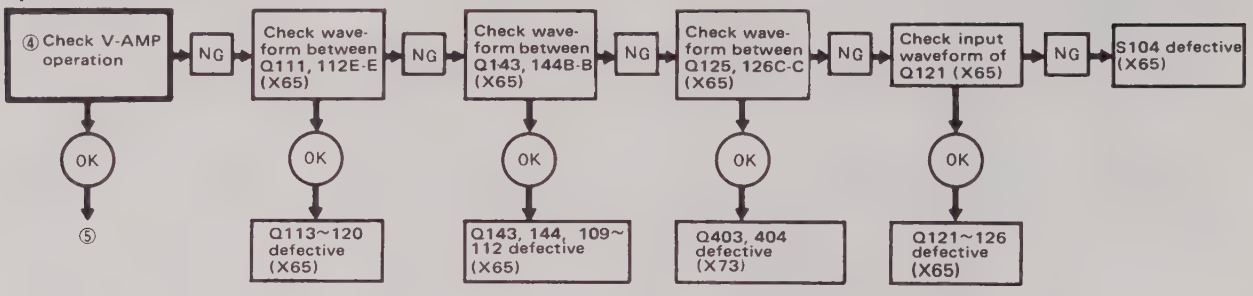
1. Add sine wave of 1 kHz, 2V to HOR, INPUT terminal.
2. Add sine wave of 2 kHz to vertical input terminal.

Fig. 6 Waveform in SWEEP Circuit (Input Signal 2 kHz, Sine Wave) (SWEEP TIME 0.1 mS/DIV) (X74)



Note: Add sine wave of 2 kHz to vertical input terminal when checking items No. 4~8 (except No. 7).

4



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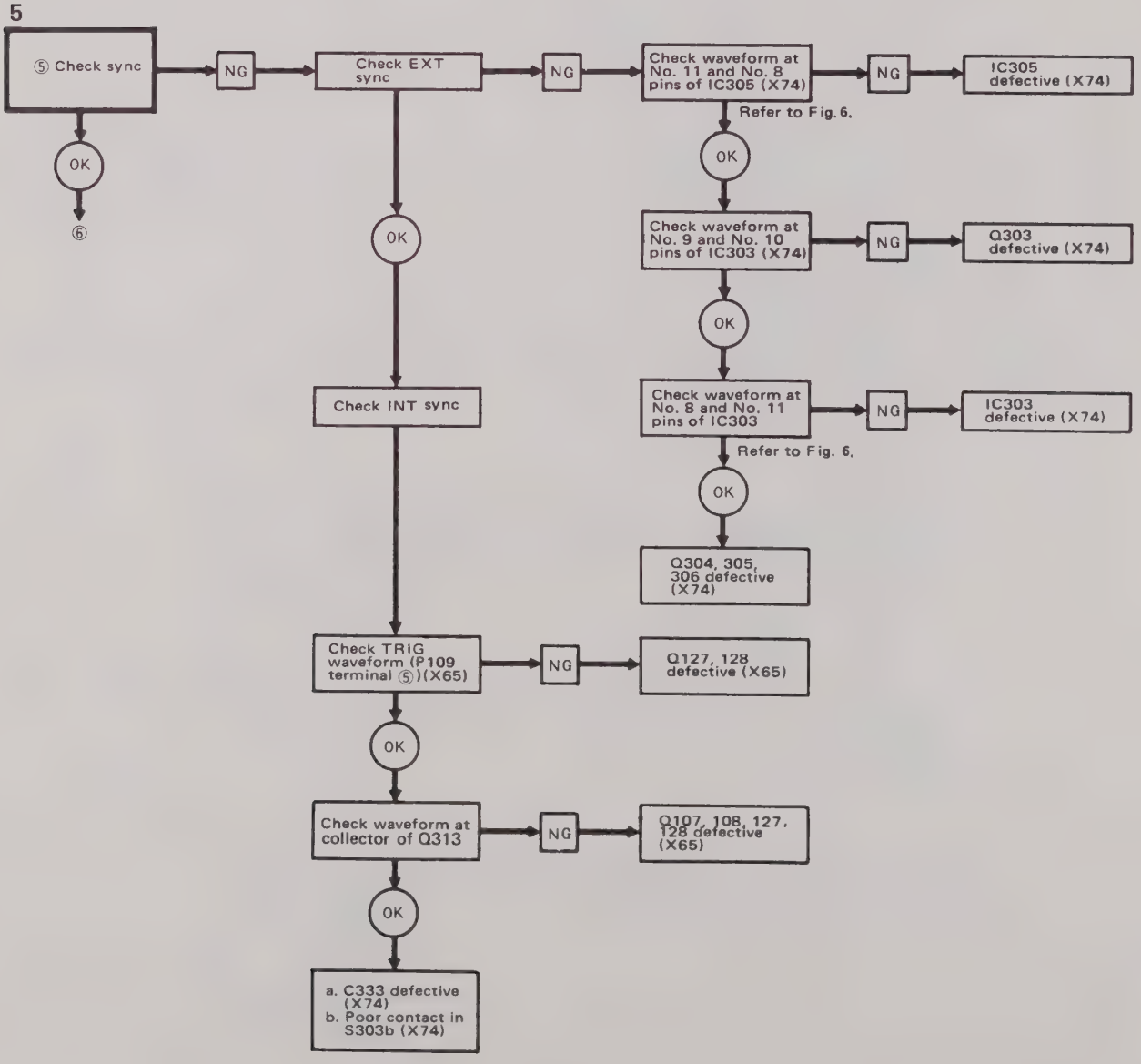

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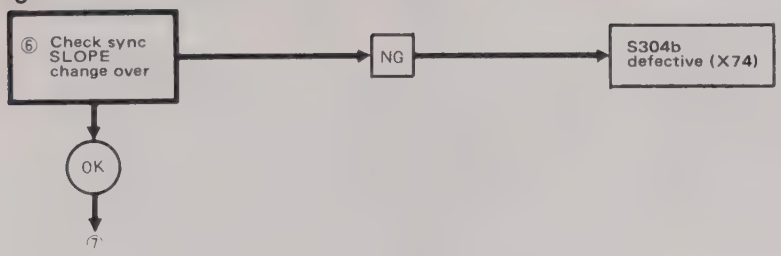

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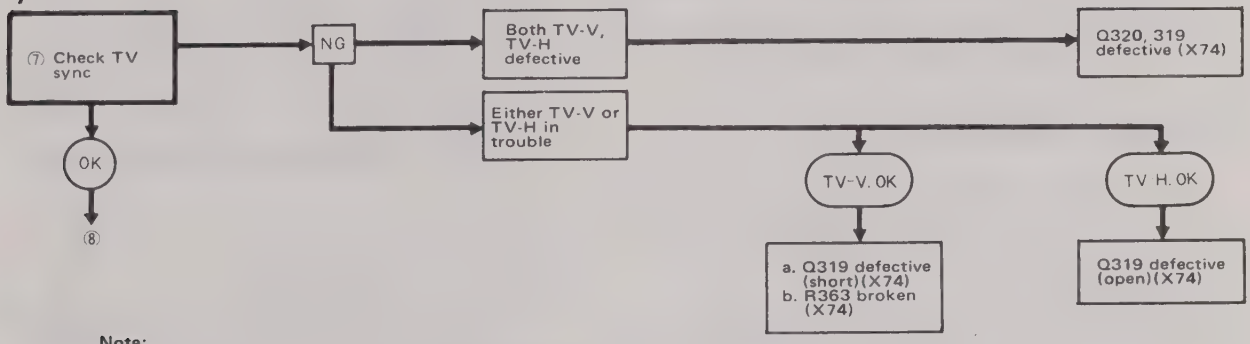
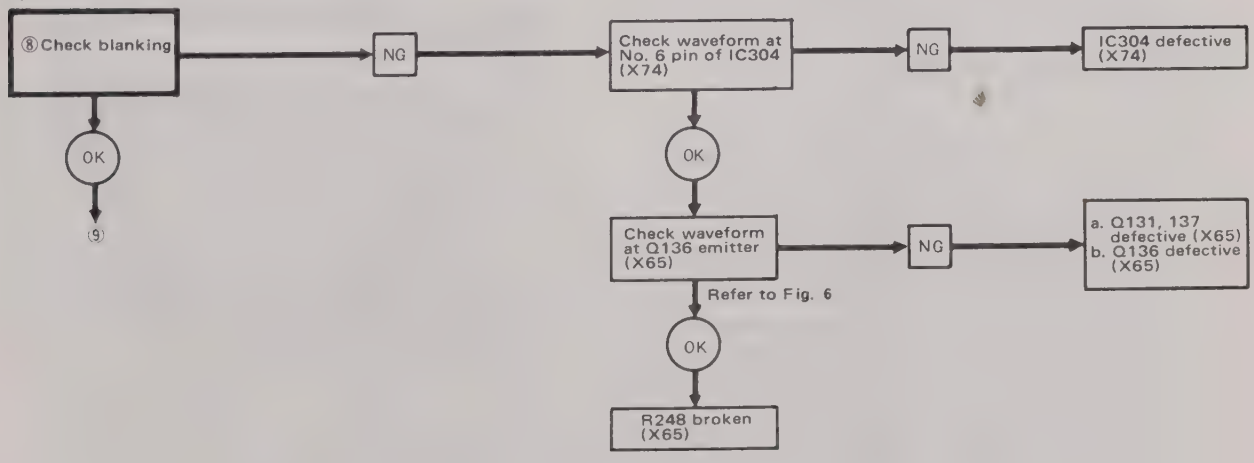


Note:
Add image signal from TV set to vertical input terminal.

8



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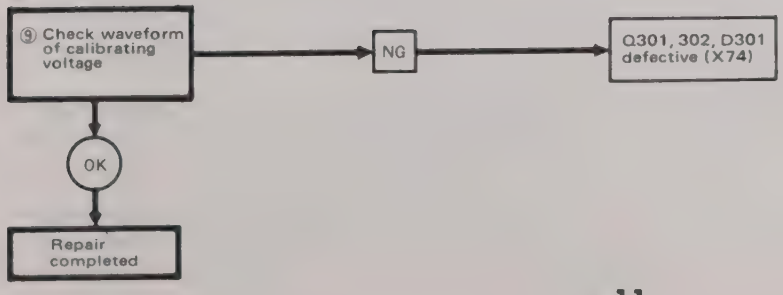


OBSERVE THE FOLLOWING BEFORE MAKING ADJUSTMENTS

1. The items given below are pre-adjusted at the factory before shipment. Should re-adjustment be required, it should be performed after calibrating the power source voltage (no adjustment is required on the probe).
2. All adjustments should be made with the semi-fixed resistors or the trimmers mounted on the printed circuit board. For adjustment, use a well insulated, flat blade screwdriver.
3. A high voltage (2000V) is present on the lower circuit board.
   Be sure to turn off the power before removing the bottom cover.
4. For optimum adjustment, turn on the power and warm up the oscilloscope sufficiently before starting.

DC BAL (1) ADJUSTMENT

This adjustment is required when the bright line moves up and down by turning the vertical attenuator (VOLTS/DIV).

1. Set the vertical input selector switch (AC-GND-DC) to GND. Then center the bright line by pulling the PULL AUTO knob.
2. Turn the vertical attenuator (VARIABLE) fully counterclockwise. Adjust VR111 through the hoel on the left side of the case so that the bright line is not deflected as the attenuator VOLTS/DIV is turned.

DC BAL (2) ADJUSTMENT

This adjustment is required when the bright line moves up or down by turning the vertical attenuator VARIABLE.

1. Remove the case as described previously. For adjustment, use the auxiliary printed circuit board on the bottom. Adjust the VR402 from the top.
2. Turn the variable attenuator VARIABLE fully counterclockwise so that the bright line is centered on the scale. Then, turn the attenuator (VARIABLE) fully clockwise. If, at this time, the bright line shifts up or down, adjust the VR402 until it stays in the center position.
3. Repeat the above procedures until the bright line is stabilized when the attenuator (VARIABLE) is rotated.

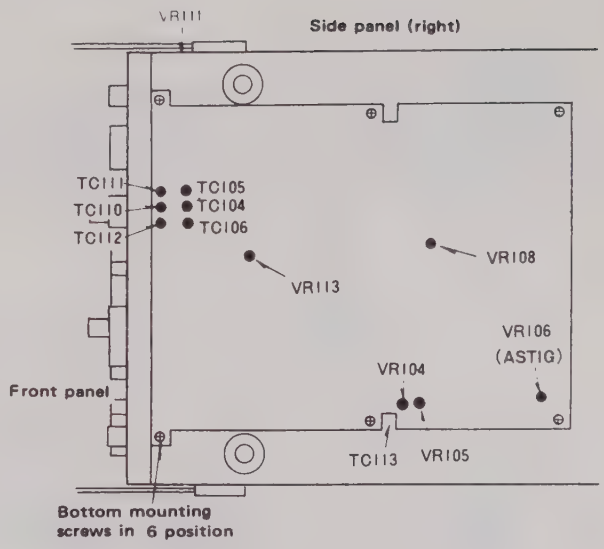


Fig. 7 Adjusting Holes on the Bottom Cover

POWER TRANSFORMER

This oscilloscope is pre-adjusted for 240V AC operation (adjustable for 100V, 120V or 220V AC operation).

VERTICAL ATTENUATOR ADJUSTMENT (VOLTS/DIV)

1. This adjustment should be made with the trimmer capacitor on the lower circuit board, which is accessible through the adjusting hoel provided on the bottom cover.
2. Connect a 1 kHz (output: 0.5V to 100V p-p) square wave signal generator to the vertical input terminal.
3. With VOLTS/DIV set to 0.1V, adjust the trimmer TC 104 until optimum square wave is obtained.
4. Next, change the range to 1V and 10V and adjust the trimmers in the same manner.

ADJUSTMENTS

PROBE AND INPUT CAPACITANCE ADJUSTMENT

1. Set VOLTS to 0.01V.
2. Set the probe to 10 : 1 and connect it to INPUT terminal. Apply 1 kHz square wave signal to the probe and adjust its trimmer for optimum square wave. In this case, the input voltage is attenuated to 1/10 but the input resistance and input capacitance are reduced to less than 10 M ohms and 18 pF respectively.
3. Next, set VOLTS to 0.1V and adjust the trimmer. TC 110 on the lower circuit board through the adjusting hole provided on the bottom case so that optimum square wave can be obtained.
4. Finally adjust the trimmers TC111 and TC112 at 1V and 10V ranges respectively.

VERTICAL SENSITIVITY ADJUSTMENT

1. Set VOLTS/DIV to 0.01V and turn VARIABLE fully clockwise to CAL.
2. Apply 0.05V p-p square wave signal to the vertical input.
3. Adjust VR113 (GAIN ADJ) on the lower circuit board through the adjusting hole in the bottom cover for 5 div of vertical amplitude.

CRT CENTERING ADJUSTMENT

1. Remove the case according to the procedures described under "Removing the Case".
2. Short the test terminals TP101 and TP102 on the lower circuit board.
3. With a horizontal bright line displayed on CRT, adjust VR105 on the same circuit board until the bright line is centered.

FREQUENCY RESPONSE AND OVERSHOOT ADJUSTMENT

1. Apply 100 kHz square wave signal having a good rise characteristic to theiinput.
2. Adjust the middle range of the square wave (after rising) with TC113 on the lower circuit board through the adjusting hole in the bottom cover.
3. Adjust the high range of the square wave (rising portion) with VR104 on the same circuit board through the adjusting hole in the bottom cover.

SWEEP TIME (HORIZONTAL SENSITIVITY) AND BRIGHT LINE LENGTH ADJUSTMENT

1. Remove the case according to the procedures described under "Removing the Case".
2. Set SWEEP TIME/DIV to 0.1 ms and turn VARIABLE fully clockwise to CAL.
3. Apply 1 kHz calibrated sine wave signal to the input and adjust each POSITION so that the waveform is centered and its starting point is positioned to the extreme left of the scale.
4. Adjust VR306 (TIME ADJ) on the side circuit board so that 1 wave length of the sine wave is 10 div on the scale. At this time, the length of the horizontal bright line will vary.
   Adjust it with VR309 (LENGTH ADJ) on the same circuit board. This adjustment varies only the end portion of the waveform, so the length of the bright line can be adjusted without affecting the starting point and the sweep time.
   During the adjustment, manipulate◀▶ POSITION and TRIG LEVEL in order that the starting point may always be held in the center of the extreme left of the scale.
5. The above adjustment applies to the ranges of 0.5s to 0.1ms. For the ranges of 50μs to 1μs, adjust TC301 on the side circuit board.

X 5 MAG ADJUSTMENT

1. Set SWEEP TIME/DIV switch to 1 ms/div and apply 1 kHz sine wave signal to the input.
2. Adjust the oscillator frequency and ◀▶ POSITION to obtain 11 peaks of waveforms. Each peak should be on the vertical line on the scale.
3. With MAG switch pulled toward you, adjust VR303 (MAG ADJ) on the side circuit board so that the spacing between peaks is 5 div.

MAG CENTER ADJUSTMENT

1. Set SWEEP TIME/DIV to 0.1ms and apply 1 kHz square wave signal to the input. Adjust so that 1 wave length is spread over the entire scale.
2. Set ◀▶ POSITION to its mechanical center position (waveform may deviate in the horizontal direction).
3. With MAG switch pulled toward you, adjust VR304 (MAG CENT) on the side circuit board until the rising portion (or falling portion) in the center of the waveform comes to the point obtained at "X1" (MAG switch depressed).
4. Repeat this adjustment until the position of the rising portion (or falling portion) in the center of the waveform is not varied regardless of the position of the MAG switch.
5. Return MAG switch to "X1" and adjust VR305 (POS ADJ) on the side circuit board until the starting point of the waveform comes to the extreme left of the scale.

HORIZONTAL POSITION ADJUSTMENT

1. To adjust the horizontal position during sweep time, proceed as follows:
   Set ◄► POSITION to its mechanical center position and adjust VR305 (POS ADJ) on the side circuit board until the starting point of the waveform comes to the extreme left of the scale.
2. When SWEEP TIME/DIV is set to EXT H, adjust VR 308 on the same circuit board so that the spot comes to the center of the scale.

SYNCHRONIZING LEVEL ADJUSTMENT

1. Apply 1 kHz sine wave signal to the input. Set SYNC switch to NORM and SOURCE switch to INT.
2. Adjust VR311 (TRIG ADJ) on the side circuit board so that the waveform is started at the same position on the reverse slope when SLOPE is switched to "+" and "−".

CALIBRATING VOLTAGE ADJUSTMENT

Adjust VR301 on the side circuit board for 1 V p-p of square wave calibrating output voltage.

ASTIG ADJUSTMENT

Adjust VR106 on the lower circuit board through the adjusting hole in the bottom cover to uniform the width of the waveform bright line while adjusting FOCUS. Once adjusted, no readjustment is required because ASTIG is stabilized.

HIGH VOLTAGE ADJUSTMENT

1. Connect a DC voltmeter having high input impedance (more than 100M ohms) to CRT's socket terminal 1 or 3 and to the chassis.
2. Adjust VR107 on the lower circuit board for a reading of −1.9kV on the voltmeter.

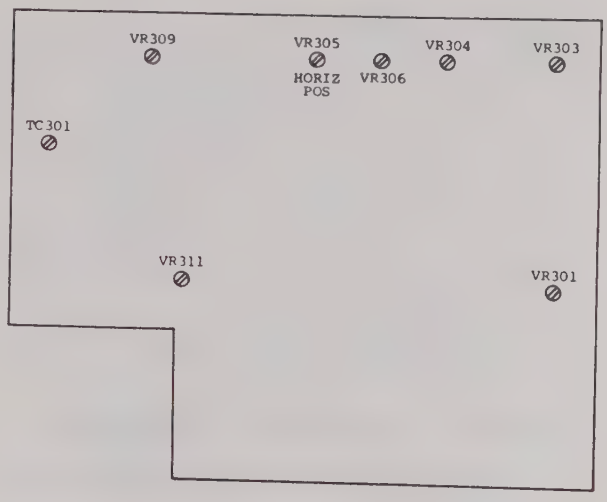
BLANKING VOLTAGE ADJUSTMENT

1. By using PULL AUTO, display a bright line on the screen of CRT.
2. Adjust VR108 on the lower circuit board through the adjusting hoel in the bottom cover so that the bright line disappears at 9 ~ 11 o'clock position of the brightness control knob.

180V ADJUSTMENT

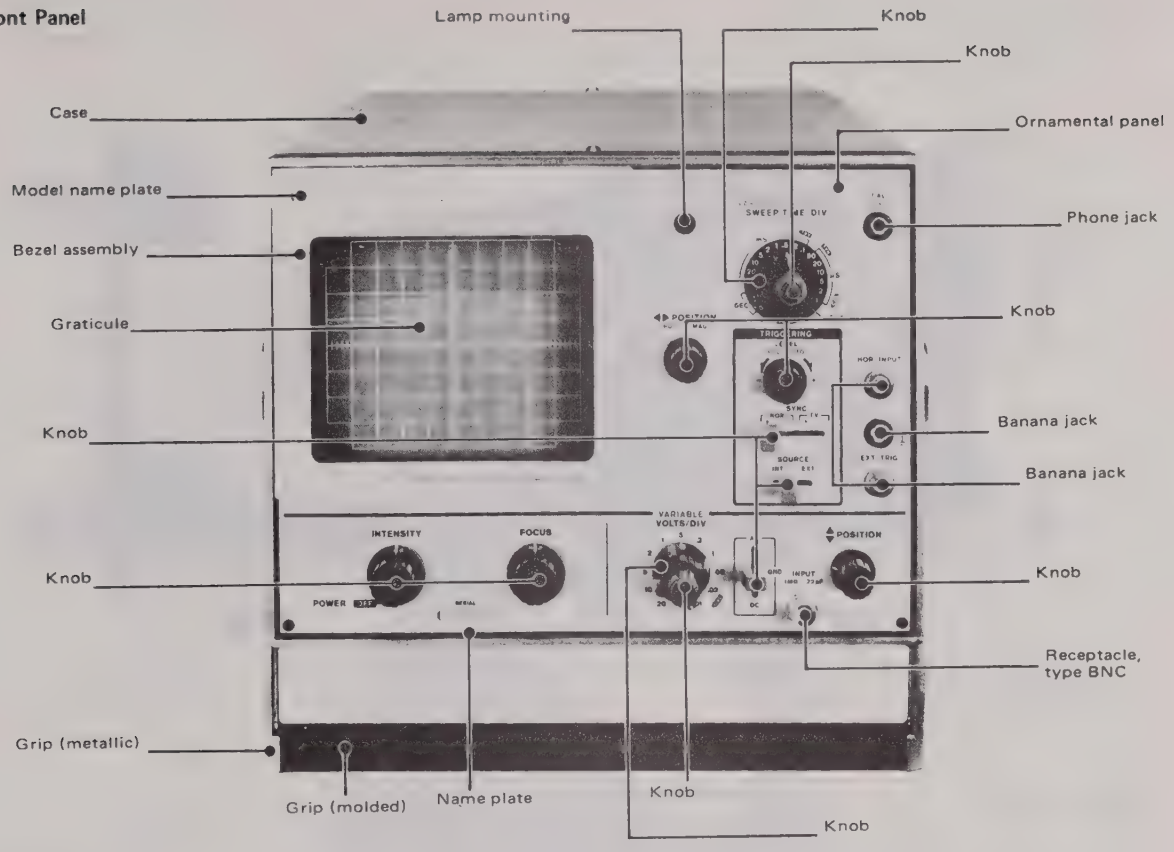
Adjust VR109 on the lower circuit board until the voltage of No. 15 pin of the connector P110 on the same circuit board reaches 180V.

Fig. 8 Adjustment Points of Printed Circuit Board (X74)

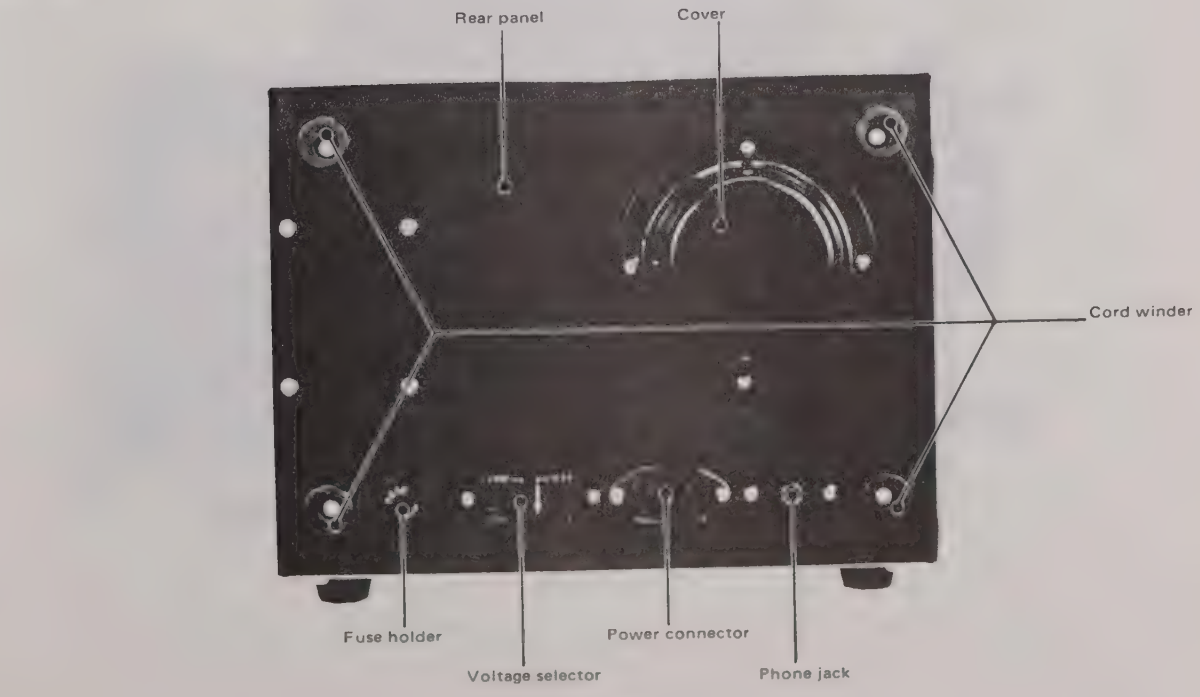


PARTS ALIGNMENT

Front Panel

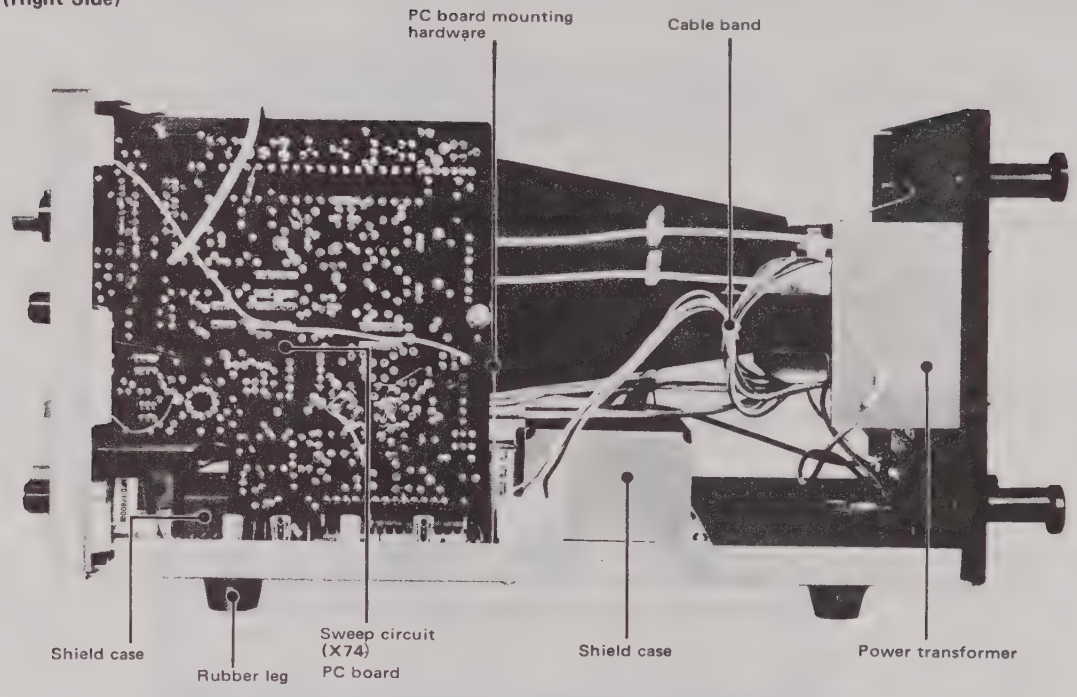


Rear Panel

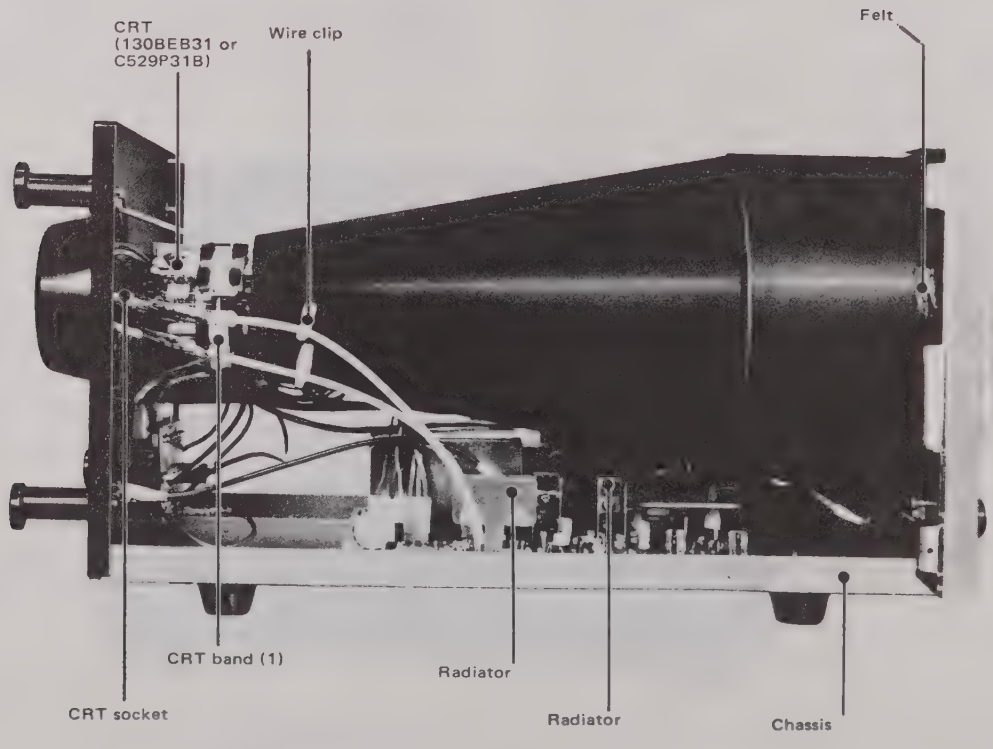


PARTS ALIGNMENT

Chassis (Right Side)

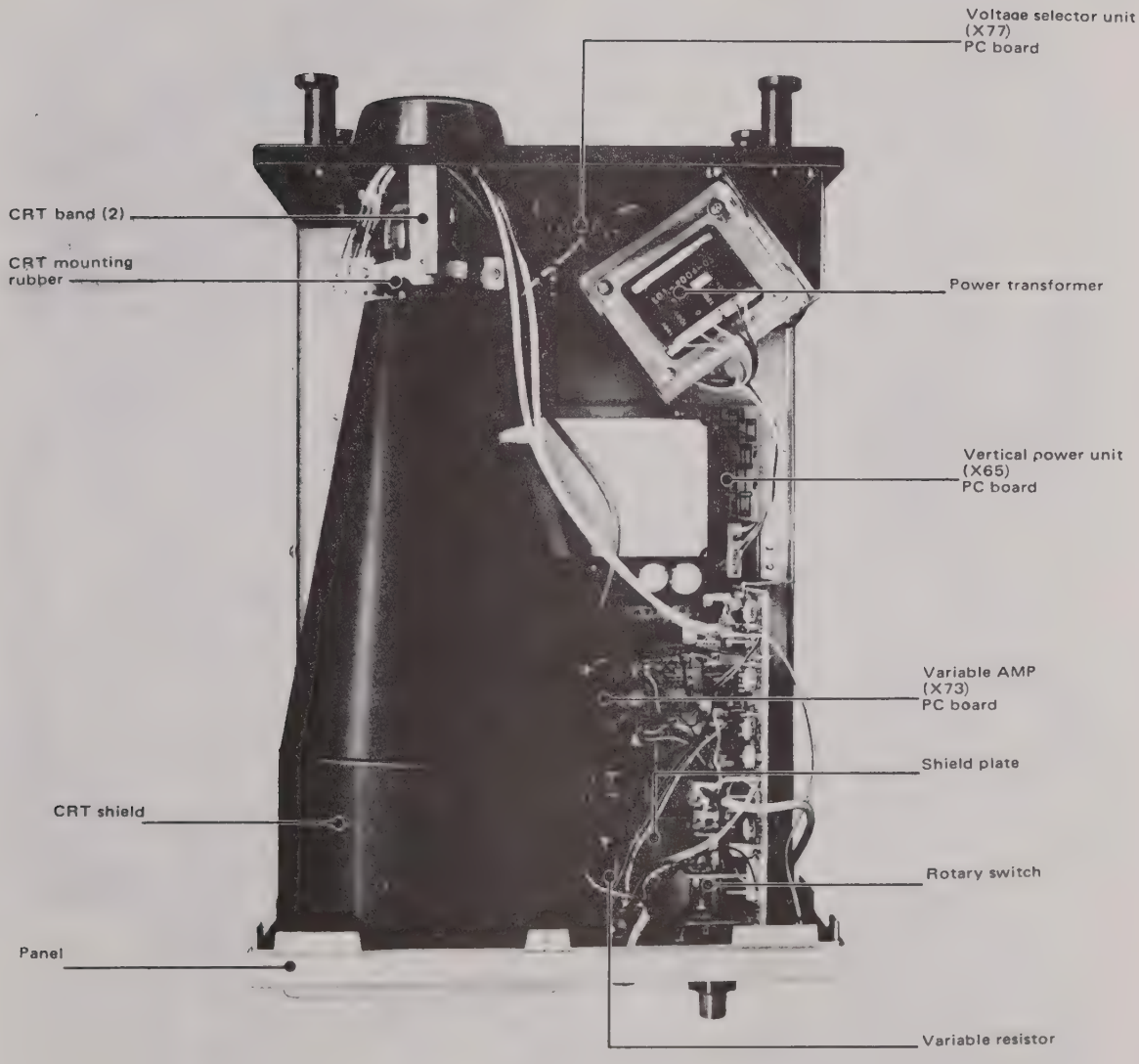


Chassis (Left Side)

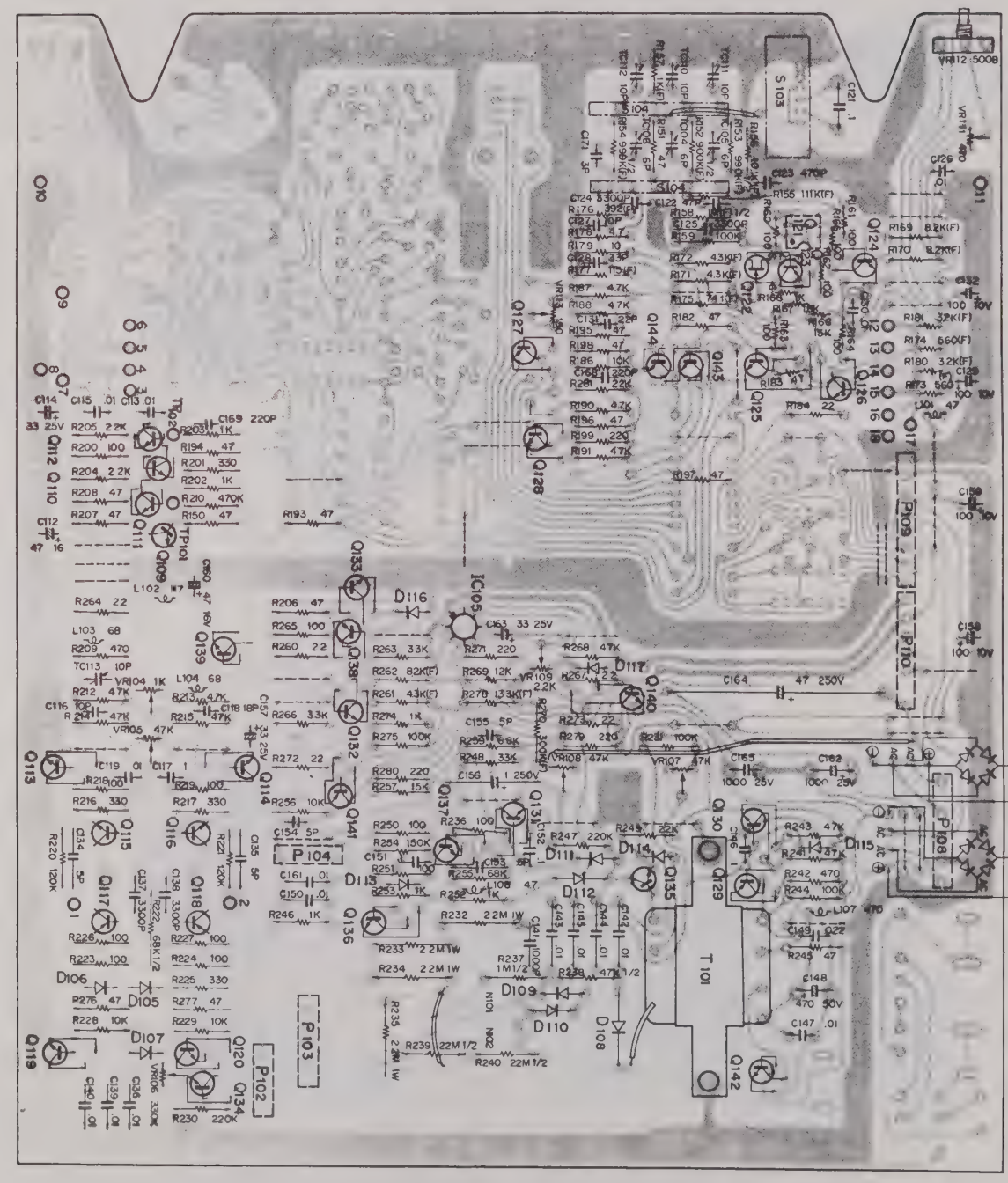


PARTS ALIGNMENT

Chassis (Upper)



▼ VERTICAL POWER UNIT (X65)



Q109~112, 119, 120, 123, 124, 130, 132, 133:2SC945-P, Q113, 114, 125, 126, 131, 143, 144:2SC535-C, Q115, 116:2SC1628-Y, Q117, 118:2SA818-Y, Q121:E412S-B, Q122:2SK30A-O, Q127~129:2SA733-Q, Q134~137:2SC983-Y, Q138:2SC1213-C, Q139:2SC1419-C, Q140:2SA755-C, Q141:2SB536(2)LM, Q142:2SD401, IC105:RC4558T, D105, 106, 114, 115:1S1555, D107, 116:WZ100, D108:Y16JA, D109~111:W06C, D112:1S1705, D113:WZ050, D117:WZ090, D118, 119:S1QB60

PARTS LIST

NOTE:

Standard value resistors and capacitors are not listed. Minimum charge $5.00 per invoice. Orders will be shipped C.O.D. unless previous open account arrangements have been made or remittance accompanies order. Advance remittance must cover postage or express charges. Specify serial number when ordering replacement parts.

MAIN CHASSIS AND CABINET PARTS

Ref. No.	Part No.	Description
R1, 2	002-104-5-331	Carbon, 330Ω, ±5%, 1/4 W
VR1	008-235-9-001	Variable Resistor, 3MΩ
VR2, S1	008-235-9-004	Variable Resistor w/Switch 1KΩ B
VR3	008-282-9-001	Variable Resistor w/Switch 5KΩ B x 2
L1, 2	041-068-9-001	Fixed Inductor (Small Type) 3.3μH
T1	065-124-9-001	Power Transformer
	230-012-9-001	CRT
	272-111-9-001	Case
	257-082-9-001	Chassis
	255-141-9-001	Panel
	260-087-9-001	Ornamental Panel
	262-014-9-001	Rear Panel
	252-020-9-001	Bottom Plate
	482-044-9-001	Graticule
	752-010-9-001	Lamp Mounting
	600-029-9-001	Name Plate
	483-252-9-001	Model Name Plate
	483-228-9-001	Name Plate (Power Source)
	480-180-9-001	Instruction Manual
	749-080-9-001	CRT Socket
J11		Power Connector
J1	773-071-9-001	Receptacle, Type BNC
J10	773-035-9-001	Phone Jack
J5	773-051-9-002	Phone Jack
	775-021-9-001	Phone Plug
J6, 9	773-050-9-001	Banana Jack
J7	773-050-9-002	Banana Jack (Black)
	740-017-9-001	Grounding Plate
	527-064-9-001	Lead Wire w/1P Connector
	527-068-9-001	Lead Wire w/3P Connector
	527-068-9-003	Lead Wire w/4P Connector
	527-068-9-002	Lead Wire w/3P Connector
		Lead Wire w/4P Connector
		Lead Wire w/1P Connector
	191-010-9-001	Fuse, 0.3A
	191-011-9-001	Fuse, 0.7A
	253-050-9-001	Cover
	256-056-9-001	Shield Plate
	256-057-9-001	Shield Case
	256-058-9-001	CRT Shield
		Felt (170 x 10)
		Felt (420 x 20 x 12)
		Spring
		CRT Mounting Rubber x 2
		Bezel Bush
		Packing Material, Foamed Styrene
	502-093-9-001	Packing Case
		Protection Cover
		Polyethylene Bag
	381-069-9-001	Rubber Leg
	380-266-9-002	Bezel Assembly
	380-266-9-003	Bezel
		Fuse Holder
		Wire Clip
		CRT Band (1)
		CRT Band (2)
	251-182-9-001	Power Transformer Mounting Hardware
	251-183-9-001	PC Board Mounting Hardware
	251-184-9-001	Grip Mounting Hardware
		Spacer (Volume)
		Bush
		Support x 3
		Cable Band x 5
	745-033-9-001	Grip Assembly
		Grip (Metallic)
		Grip (Molded)
	751-120-9-001	Knob x 2
	751-138-9-002	Knob x 2
	751-124-9-001	Knob x 3
	751-138-9-001	Knob x 2
	751-138-9-003	Knob x 3
		Cord Winder
	523-155-9-001	Vertical Power Unit
	523-155-9-002	Variable AMP Unit
	523-155-9-003	Sweep Circuit Unit
		Voltage Selector Unit
		CEE Cord
		Probe (PC-21)

VERTICAL AMP/POWER SUPPLY UNIT (X65)

RESISTORS

Ref. No.	Part No.	Description
R150, 151	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R152	013-010-9-011	Metal Film, 900KΩ, ±1%, 1/2 W
R153	013-010-9-012	Metal Film, 990KΩ, ±1%, 1/2 W
R154	013-010-9-013	Metal Film, 999KΩ, ±1%, 1/2 W
R155	013-010-9-010	Metal Film, 111KΩ, ±1%, 1/4 W
R156	013-010-9-008	Metal Film, 10.1KΩ, ±1%, 1/4 W
R157	013-010-9-004	Metal Film, 1KΩ, ±1%, 1/4 W
R158	013-008-9-023	Metal Film, 1MΩ, ±1%, 1/2 W
R159	002-104-9-104	Carbon, 100KΩ, ±5%, 1/4 W
R160-165	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R166	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R167, 168	002-104-5-153	Carbon, 15KΩ, ±5%, 1/4 W
R169, 170	013-010-9-007	Metal Film, 8.2KΩ, ±1%, 1/4 W
R171, 172	013-010-9-005	Metal Film, 4.3KΩ, ±1%, 1/4 W
R173, 174	004-164-9-001	Metal Film, 560Ω, ±1%, 1/4 W
R175		Metal Film, 741Ω, ±1%, 1/4 W
R176		Metal Film, 392Ω, ±1%, 1/4 W
R177		Metal Film, 115Ω, ±1%, 1/4 W
R178	002-104-5-479	Carbon, 4.7Ω, ±5%, 1/4 W
R179	002-104-5-100	Carbon, 10Ω, ±5%, 1/4 W
R180, 181	004-164-9-002	Metal Film, 3.2KΩ, ±1%, 1/4 W
R182	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R183	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R184	002-104-5-220	Carbon, 22z , ±5%, 1/4 W
R186	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R187, 188	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R190, 191	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R193-198	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R199	002-104-5-221	Carbon, 220Ω, ±5%, 1/4 W
R200	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R201	002-104-5-331	Carbon, 330Ω, ±5%, 1/4 W
R202, 203	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R204, 205	002-104-5-222	Carbon, 2.2KΩ, ±5%, 1/4 W
R206-208	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R209	002-104-5-471	Carbon, 470Ω, ±5%, 1/4 W
R210	002-104-5-474	Carbon, 470KΩ, ±5%, 1/4 W
R212, 213	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R214, 215	002-104-5-473	Carbon, 47KΩ, ±5%, 1/4 W
R216, 217	002-104-5-331	Carbon, 330Ω, ±5%, 1/4 W
R218, 219	002-104-5-101	Carbon, 100Ω, ±5%, 1/4W
R220, 221	002-104-5-124	Carbon, 120KΩ, ±5%, 1/4 W
R222	001-102-5-683	Carbon, 68KΩ, ±5%, 1/2 W
R223, 224	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R225	002-104-5-331	Carbon, 330Ω, ±5%, 1/4 W
R226, 227	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R228, 229	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R230	002-104-5-224	Carbon, 220KΩ, ±5%, 1/4 W
R231	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R232-235	004-164-9-003	Carbon, 2.2MΩ, ±5%, 1W
R236	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R237	001-102-5-106	Carbon, 1MΩ, ±5%, 1/2 W
R238	001-102-5-473	Carbon, 47KΩ, ±5%, 1/2 W
R239, 240	001-102-5-226	Carbon, 22MΩ, ±10%, 1/2 W
R241	002-104-5-473	Carbon, 47KΩ, ±5%, 1/4 W
R242	002-104-5-471	Carbon, 470Ω, ±5%, 1/4 W
R243	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R244	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R245	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R246	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R247	002-104-5-224	Carbon, 220KΩ, ±5%, 1/4 W
R248	002-104-5-333	Carbon, 33KΩ, ±5%, 1/4 W
R249	002-104-5-223	Carbon, 22KΩ, ±5%, 1/4 W
R250, 251	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R252, 253	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R254	002-104-5-154	Carbon, 150KΩ, ±5%, 1/4 W

PARTS LIST

VERTICAL AMP/POWER SUPPLY UNIT(Cont'd.)

RESISTORS(Cont'd.)

Ref. No.	Part No.	Description
R255	002-104-5-683	Carbon, 68KΩ, ±5%, 1/4 W
R256	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R257	002-104-5-153	Carbon, 15KΩ, ±5%, 1/4 W
R259	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R260	002-104-5-229	Carbon, 2.2Ω, ±5%, 1/4 W
R261	013-010-9-005	Metal Film, 4.3KΩ, ±1%, 1/4 W
R262	013-010-9-007	Metal Film, 8.2KΩ, ±1%, 1/4 W
R263	002-104-5-332	Carbon, 3.3KΩ, ±5%, 1/4 W
R264	002-104-5-220	Carbon, 2.2Ω, ±5%, 1/4 W
R265	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R266	002-104-5-332	Carbon, 3.3KΩ, ±5%, 1/4 W
R267	002-104-5-229	Carbon, 2.2Ω, ±5%, 1/4 W
R268	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R269	002-104-5-123	Carbon, 12KΩ, ±5%, 1/4 W
R270	013-008-9-021	Metal Film, 300KΩ, ±1%, 1/4 W
R271	002-104-5-221	Carbon, 220Ω, ±5%, 1/4 W
R272, 273	002-104-5-220	Carbon, 22Ω, ±5%, 1/4 W
R274	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R275	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R276, 277	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R278	013-010-9-009	Metal Film, 13.3KΩ, ±1%, 1/4 W
R279, 280	002-104-5-221	Carbon, 220Ω, ±5%, 1/4 W
R281	002-104-5-223	Carbon, 22KΩ, ±5%, 1/4 W
	004-152-9-002	Jumper Resistor

CAPACITORS

C112	022-090-9-003	Electrolytic, 47μF, 16WV
C113	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C114	022-135-9-001	Electrolytic, 33μF, 25WV
C115	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C116	020-163-9-003	Ceramic, 10pF, ±0.5pF
C117	033-018-9-001	Ceramic, 0.1μF, +80%,-20%
C118	020-163-9-004	Ceramic, 18pF, ±5%
C119	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C121	033-018-9-002	Metal Film, 0.1μF
C122	023-052-9-001	Mica, 47pF, ±5%
C123	023-049-9-001	Mica, 470pF, ±5%
C124		Mylar, 3300pF, ±10%
C125		Mylar, 3300pF, ±10%
C126		Ceramic, 0.01μF, +100%,-0%
C127	020-163-9-003	Ceramic, 10pF, ±0.5pF
C128	020-144-9-003	Ceramic, 33pF, ±5%
C129	022-123-9-002	Electrolytic, 100μF, 10WV
C130	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C131	020-124-9-007	Ceramic, 22pF, ±5%
C132	022-123-9-002	Electrolytic, 100μF, 10WV
C134, 135	033-019-9-001	Condenser, 0.5pF
C136	020-111-9-002	Ceramic, 0.01μF, ±20%
C137, 138	020-149-9-004	Ceramic, 3300pF, ±20%
C139, 140	020-111-9-002	Ceramic, 0.01μF, ±20%
C141	020-142-9-005	Ceramic, 1000pF, +100%,-0%
C142-145	020-163-9-005	Ceramic, 0.01μF, +100%,-0%
C146	033-018-9-001	Ceramic, 0.1μF, +80%,-20%
C147	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C148	022-135-9-003	Electrolytic, 470μF, 50WV
C149	025-107-9-002	Mylar, 0.022μF, ±10%
C150	020-111-9-012	Ceramic, 0.01μF, ±20%
C151, 152	033-018-9-001	Ceramic, 0.1μF, +80%,-20%
C153	033-019-9-001	Condenser, 0.5pF
C154, 155	020-163-9-002	Ceramic, 5pF, ±0.5pF
C156	021-039-9-001	Electrolytic, 1μF, 250WV
C157	022-135-9-001	Electrolytic, 33μF, 25WV
C158, 159	022-123-9-002	Electrolytic, 100μF, 10WV
C160	022-090-9-003	Electrolytic 47μF, 16WV
C161	020-111-9-002	Ceramic, 0.1μF, ±20%
C162	022-135-9-002	Electrolytic, 1000μF, 25WV
C163	022-135-9-001	Electrolytic, 33μF, 25WV
C164	021-057-9-001	Electrolytic, 47μF, 250WV
C165	022-135-9-002	Electrolytic, 1000μF, 25WV
C168, 169	020-124-9-008	Ceramic, 220pF, ±5%
C171	020-160-9-001	Ceramic, 3pF, ±0.5pF

SEMICONDUCTORS

Q109-112	176-055-9-002	Transistor, 2SC945-P
Q113, 114	176-055-9-001	Transistor, 2SC535-C
Q115, 116	176-055-9-005	Transistor, 2SC1628-Y
Q117, 118	177-018-9-003	Transistor, 2SA818-Y

SEMICONDUCTORS(Cont'd.)

Q119, 120	176-055-9-002	Transistor, 2SC945-P
Q121	182-039-9-001	FET, E412S-B
Q122	182-026-9-001	FET, 2SK30A-O
Q123, 124	176-055-9-002	Transistor, 2SC945-P
Q125, 126	176-055-9-001	Transistor, 2SC535-C
Q127-129	177-018-9-001	Transistor, 2SA733-Q
Q130	176-055-9-002	Transistor, 2SC945-P
Q131	176-055-9-001	Transistor, 2SC535-C
Q132, 133	176-055-9-002	Transistor, 2SC945-P
Q134-137	176-053-9-002	Transistor, 2SC983-Y
Q138	176-055-9-003	Transistor, 2SC1213-C
Q139	176-055-9-004	Transistor, 2SC1419-C
Q140	177-018-9-002	Transistor, 2SA755-C
Q141	173-004-9-001	Transistor 2SB536(2)LM
Q142	172-037-9-001	Transistor, 2SD401
Q143, 144	176-055-9-001	Transistor, 2SC535-C
IC105	307-069-9-005	IC, RC4558T
D105, 106	155-028-9-007	Diode, 1S1555
D107	152-050-9-001	Diode, WZ100
D108	151-048-9-003	Diode, Y16JA
D109-111	151-052-9-002	Diode, W06C
D112	151-052-9-001	Diode, 1S1705
D113	152-069-9-001	Diode, WZ050
D114, 115	155-028-9-007	Diode, 1S1555
D116	152-050-9-001	Diode, WZ100
D117	152-069-9-002	Diode, WZ090
D118, 119	157-006-9-001	Diode, S1QB60

POTENTIOMETERS

VR104	008-155-9-005	Semi-Fixed Resistor, 1KΩ
VR105	008-169-9-008	Semi-Fixed Resistor, 47KΩ
VR106	008-163-9-010	Semi-Fixed Resistor, 330KΩ
VR107, 108	008-169-9-008	Semi-Fixed Resistor, 47KΩ
VR109	008-233-9-002	Semi-Fixed Resistor, 2.2KΩ
VR111	008-235-9-002	Semi-Fixed Resistor, 470Ω
VR112		Variable Resistor, 500Ω (B)
VR113	008-233-9-001	Semi-Fixed Resistor, 150Ω
VR115	008-282-9-002	Variable Resistor, 5KΩ (A)
S103	080-003-9-001	Lever Switch
S104	083-204-9-001	Rotary Switch

MISCELLANEOUS

L101, 102	041-068-9-002	Ferri-Inductor, 47μH
L103, 104	041-068-9-009	Ferri-Inductor, 68μH
L107	041-071-9-001	Ferri-Inductor, 470μH
L108	041-068-9-008	Ferri-Inductor, 4.7μH
T101	064-015-9-001	Converter Trans
TC104-106	028-033-9-001	Trimmer, 6pF
TC110-113	028-033-9-002	Trimmer, 10pF
P102		Connector, 3P
P103		Connector, 4P
P104		Connector, 3P
P108		Connector, 5P
P109		Connector, 8P
P110		Connector, 7P
P112		Connector, 11P
N101, 102	401-018-9-001	Neon Lamp, NE-2
	757-012-9-002	Terminal
	740-017-9-002	Grounding Plate
		Heat Sink
		Heat Sink
	256-050-9-005	Shield Case
	302-201-9-001	Printed Circuit Board

VARIABLE AMP UNIT (X73)

RESISTORS

R421	002-104-5-201	Carbon, 200Ω, ±5%, 1/4 W
R422	002-104-5-681	Carbon, 680Ω, ±5%, 1/4 W
R424		Metal Film, 182Ω, , 1%, 1/4 W
R425	002-104-5-100	Carbon, 10Ω, ±5%, 1/4 W
R426		Metal Film, 182Ω, ±1%, 1/4 W
R427-429	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R430, 431	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R432	002-104-5-621	Carbon, 620Ω, ±5%, 1/4 W

CAPACITORS

C421	020-142-9-003	Ceramic, 10pF, ±0.5pF
C422	022-119-9-004	Electrolytic, 47μF, 10WV
C423, 424	033-018-9-001	Ceramic, 0.1μF, +30%,-20%
C425	022-119-9-004	Electrolytic, 47μF, 10WV

PARTS LIST

Ref. No.	Part No.	Description

VARIABLE AMP UNIT(Cont'd.)

SEMICONDUCTOR

Q403, 404	176-055-9-001	Transistor, 2SC535-C

POTENTIOMETER

VR402	008-282-9-004	Semi-Fixed Resistor, 100Ω (B)

MISCELLANEOUS

	345-033-9-001	Terminal
		Lead Wire w/11P Connector
	302-202-9-001	Printed Circuit Board

SWEEP/HORIZ AMP UNIT (X74)

RESISTORS

R301	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R302, 303	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R304	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R305	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R306	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R307	002-104-5-471	Carbon, 470Ω, ±5%, 1/4 W
R308	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R309, 310	002-104-5-152	Carbon, 1.5KΩ, ±5%, 1/4 W
R311, 312	002-104-5-223	Carbon, 22KΩ, ±5%, 1/4 W
R313-315	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R316	002-104-5-822	Carbon, 8.2KΩ, ±5%, 1/4 W
R317	002-104-5-821	Carbon, 820Ω, ±5%, 1/4 W
R318	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R319, 320	002-104-5-332	Carbon, 3.3KΩ, ±5%, 1/4 W
R321	002-104-5-152	Carbon, 1.5KΩ, ±5%, 1/4 W
R322	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R323	002-104-5-683	Carbon, 68KΩ, ±5%, 1/4 W
R324	013-010-9-015	Metal Graze Resistor, 3MΩ, ±1%, 1/4 W
R325	013-008-9-020	Metal Film, 100KΩ, ±1%, 1/4 W
R326	013-008-9-021	Metal Film, 300KΩ, ±1%, 1/4 W
R327	013-008-9-022	Metal Film, 500KΩ, ±1%, 1/2 W
R328	018-008-9-023	Metal Film, 1MΩ, ±1%, 1/2 W
R329	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R330	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R331	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R336	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R337, 338	002-104-5-153	Carbon, 15KΩ, ±5%, 1/4 W
R339-344	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R345, 346	013-010-9-016	Oxidized Metal Film, 15KΩ, ±2%, 2 W
R347	013-010-9-018	Metal Film, 680Ω, ±1%, 1/4 W
R348,349	002-104-5-470	Carbon, 47Ω, ±5%, 1/4 W
R350, 351	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R353	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R354	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R355	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R356	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R357	002-104-5-152	Carbon, 1.5KΩ, ±5%, 1/4 W
R358	002-104-5-332	Carbon, 3.3KΩ, ±5%, 1/4 W
R359	002-104-5-123	Carbon, 12KΩ, ±5%, 1/4 W
R360	002-104-5-123	Carbon, 12KΩ, ±5%, 1/4 W
R361	002-104-5-183	Carbon, 18KΩ, ±5%, 1/4 W
R363	002-104-5-473	Carbon, 47KΩ, ±5%, 1/4 W
R364	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R365	002-104-5-223	Carbon, 22KΩ, ±5%, 1/4 W
R366	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
R367	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R368	002-104-5-101	Carbon, 100Ω, 5%, 1/4 W
R369	002-104-5-473	Carbon, 47KΩ , ±5%, 1/4 W
R370	002-104-5-682	Carbon, 6.8KΩ, ±5%, 1/4 W
R371	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R372	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R373	002-104-5-154	Carbon, 150KΩ, ±5%, 1/4 W
R374	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R375	002-104-5-223	Carbon, 22KΩ, ±5%, 1/4 W
R376	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R377	002-104-5-104	Carbon, 100KΩ, ±5%, 1/4 W
R378	013-010-9-017	Oxidized Metal Film, 68KΩ, ±5%, 2 W
R379	013-008-9-021	Metal Film, 100KΩ, ±1%, 1/4 W
R380, 381	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W

Ref. No.	Part No.	Description

RESISTORS(Cont'd.)

R383	002-104-5-222	Carbon, 2.2KΩ, ±5%, 1/4 W
R384	002-104-5-332	Carbon, 3.3KΩ, ±5%, 1/4 W
R385	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R386	002-104-5-102	Carbon, 1KΩ, ±5%, 1/4 W
R387	002-104-5-101	Carbon, 100Ω, ±5%, 1/4 W
R388	002-104-5-103	Carbon, 10KΩ, ±5%, 1/4 W
R389	002-104-5-182	Carbon, 1.8KΩ, ±5%, 1/4 W
R390	002-104-5-272	Carbon, 2.7KΩ, ±5%, 1/4 W
R391	002-104-5-362	Carbon, 3.6KΩ, ±5%, 1/4 W
R392	002-104-5-472	Carbon, 4.7KΩ, ±5%, 1/4 W
	004-152-9-002	Jumper Resistor

CAPACITORS

C301-303	022-073-9-001	Electrolytic, 1μF, 50WV
C304, 305	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C306	025-107-9-003	Polyester, 0.47μF, ±1%
C307	025-107-9-004	Polyester, 4700pF, ±1%
C308		Ceramic, 39pF, ±5%
C309		Ceramic, 1000pF, ±10%
C310	027-011-9-001	Tantalum, 0.22μF, 25WV
C311	025-107-9-007	Mylar, 4700pF, ±10%
C312	020-149-9-005	Ceramic, 33pF, ±5%
C316, 317	020-163-9-009	Ceramic, 0.1μF, +80%-20%
C318, 319	022-126-9-001	Electrolytic, 220μF, 10WV
C320, 321	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C322	022-086-9-002	Electrolytic, 220μF, 16WV
C323	020-111-9-002	Ceramic, 0.01μF, ±20%
C324	025-107-9-005	Mylar, 1500pF, ±10%
C325	020-163-9-008	Ceramic, 560pF, ±10%
C326-328	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C329	022-123-9-002	Electrolytic, 100μF, 10WV
C330	022-119-9-004	Electrolytic, 47μF, 10WV
C331	025-107-9-007	Mylar, 4700pF, ±10%
C332, 333	022-073-9-001	Electrolytic, 1μF, 50WV
C334	020-149-9-003	Ceramic, 5pF, ±0.5pF
C335, 336	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C338	020-142-9-005	Ceramic, 0.01μF, +100%,-0%
C341	021-059-9-001	Electrolytic, 1μF, 250WV
C342, 343	020-142-9-005	Ceramic, 0.01μF, +100%,-0%

SEMICONDUCTORS(Cont'd.)

Q301-306	176-055-9-002	Transistor, 2SC945P
Q307	177-018-9-001	Transistor, 2SA733Q
Q308	182-026-9-001	FET, 2SK30A-O
C309-316	176-055-9-002	Transistor, 2SC945P
Q317, 318	176-055-9-006	Transistor, 2SC1507
Q319-321	176-055-9-002	Transistor, 2SC945P
Q322	182-026-9-001	FET, 2SK30A-O
Q323	177-018-9-001	Transistor, 2SA733Q
IC301	307-069-9-003	IC, TD3472AP
IC302	307-094-9-001	IC, RC555DN
IC303, 304	307-069-9-004	IC, TD3400AP
IC305	307-171-9-003	IC, AN606
D301, 302	151-028-9-007	Diode, 1S1555
D304-306	151-028-9-007	Diode, 1S1555
D307	151-048-9-001	Diode, 1S1587
D308, 309	151-028-9-007	Diode, 1S1555
D311-315	151-028-9-007	Diode, 1S1555
D316		STV-3H
TH301		Thermistor, SDT-1000

POTENTIOMETERS

VR301	008-163-9-008	Semi-Fixed Resistor, 470Ω (B)
VR303	008-174-9-002	Semi-Fixed Resistor, 150Ω (B)
VR304	008-163-9-008	Semi-Fixed Resistor, 470Ω (B)
VR305	008-155-9-004	Semi-Fixed Resistor, 10KΩ (B)
VR306	008-163-9-010	Semi-Fixed Resistor, 22KΩ (B)
VR307, 312	008-282-9-003	Variable Resistor, 5KΩ , 100KΩ (B)
VR308	008-169-9-006	Semi-Fixed Resistor, 1KΩ (B)
VR309	008-155-9-002	Semi-Fixed Resistor, 4.7KΩ (B)
VR310,S305	008-226-9-003	Variable Resistor, 50KΩ (B) w/SW
VR311	008-169-9-006	Semi-Fixed Resistor, 1KΩ (B)

PARTS LIST

SWEEP/HORIZ AMP UNIT(Cont'd.)

SWITCHES

Ref. No.	Part No.	Description
S302	083-204-9-002	Rotary Switch
S303	080-004-9-001	Lever Switch
S304	080-004-9-002	Lever Switch

MISCELLANEOUS

Ref. No.	Part No.	Description
L301-303	041-068-9-002	Ferri-Inductor, 47μH
L304, 305	041-077-9-001	Ferri-Inductor, 1mH
TC301	028-033-9-002	Trimmer, 10pF
	757-012-9-002	Terminal
J310		Connector, 15P
	302-203-9-001	Printed Circuit Board

VOLTAGE SELECTOR UNIT (X77)

Ref. No.	Part No.	Description
		Voltage Selector (Receptacle)
		Voltage Selector (Plug)
	757-012-9-002	Terminal
		Connector, 2P
		Connector, 5P
		Connector, 6P
		Selector Plate
		Mold Pin x 2
		Printed Circuit Board

VOLTAGE MEASUREMENTS

VERTICAL AMP/POWER SUPPLY PRINTED CIRCUIT BOARD

Ref. No.	D	G	S
Q121a	4.8V	0V	.69V
Q121b	4.8V	0V	.69V
Q122	0V	-.43V	0V

Ref. No.	E	B	C
Q109	5.9V	6.5V	8.9V
Q110	5.9V	6.5V	9.1V
Q111	8.3V	8.9V	14V
Q112	8.2V	8.8V	14V
Q113	10.9V	11.6V	22V
Q114	10.9V	11.6V	22V
Q115	24.3V	24.9V	75.6V
Q116	24.3V	24.9V	75.6V
Q117	170V	168V	75.6V
Q118	170V	168V	75.6V
Q119	170V	170V	180V
Q120	170V	170V	180V
Q123	0.1V	4.9V	0.8V
Q124	0.1V	4.8V	0.8V
Q125	-0.7V	0.1V	2.1V
Q126	-0.7V	0.1V	2.1V
Q127	2.4V	1.8V	1.0V
Q128	2.3V	1.7V	0V
Q129	-.15V	-.71V	-18V
Q130	-8V	-7.6V	-.71V
Q131	5.2V	5.8V	24V

Ref. No.	E	B	C
Q132	0V	0.6V	5.9V
Q133	10.3V	10.9V	11.8V
Q134	75.6V	75.6V	180V
Q135	11.2V	11.2V	93V
Q136	53V	54V	176V
Q137	24V	25V	50V
Q138	5.3V	5.9V	11.1V
Q139	11.1V	12.1V	15V
Q140	-8.2V	-8.7V	-14.8V
Q141	-0.8V	-1.4V	-17.2V
Q142	-14V	-14V	-16V
Q143	1.6V	5.9V	0V
Q144	1.7V	0V	2.4V

SWEEP/HORIZONTAL AMP PRINTED CIRCUIT BOARD

Ref. No.	D	G	S
Q308	5.0V	.53V	.64V
Q322	10V 0V	-.13V	

Ref. No.	E	B	C
Q301	0V	1.05V	0.4V
Q302	0V	0.4V	0.6V

Ref. No.	E	B	C
Q303	4.0V	4.2V	5.0V
Q304	0V*	0V*	3.4V*
Q305	0V*	0V*	3.4V*
Q306	1.3V*	1.7V*	1.6V*
Q307	2.1V*	1.6V*	.54V*
Q309	0V*	.65V*	1.5V*
Q310	.82V	-2.6V	10V
Q311	8.2V	1.4V	4.7V
Q312	-1.4V	-2.6V	10V
Q313	5.7V	9.9V	6.4V
Q314	5.5V	4.8V	10.5V
Q315	4.1V	4.7V	10.5V
Q316	-.65V	0V	3.7V
Q317	10.5V	11V	137V
Q318	10.5V	11V	60V
Q319	0V	0V	4.6V
Q320	-0.6V	-0.05V	4.7V
Q321	-2.4V	-3.8V	.52V
Q323	-.59V	-1.2V	-0.6V

VARIABLE AMP PRINTED CIRCUIT BOARD

Ref. No.	E	B	C
Q403	1.3V	2.0V	2.3V
Q404	1.3V	2.0V	2.3V

CATHODE RAY TUBE

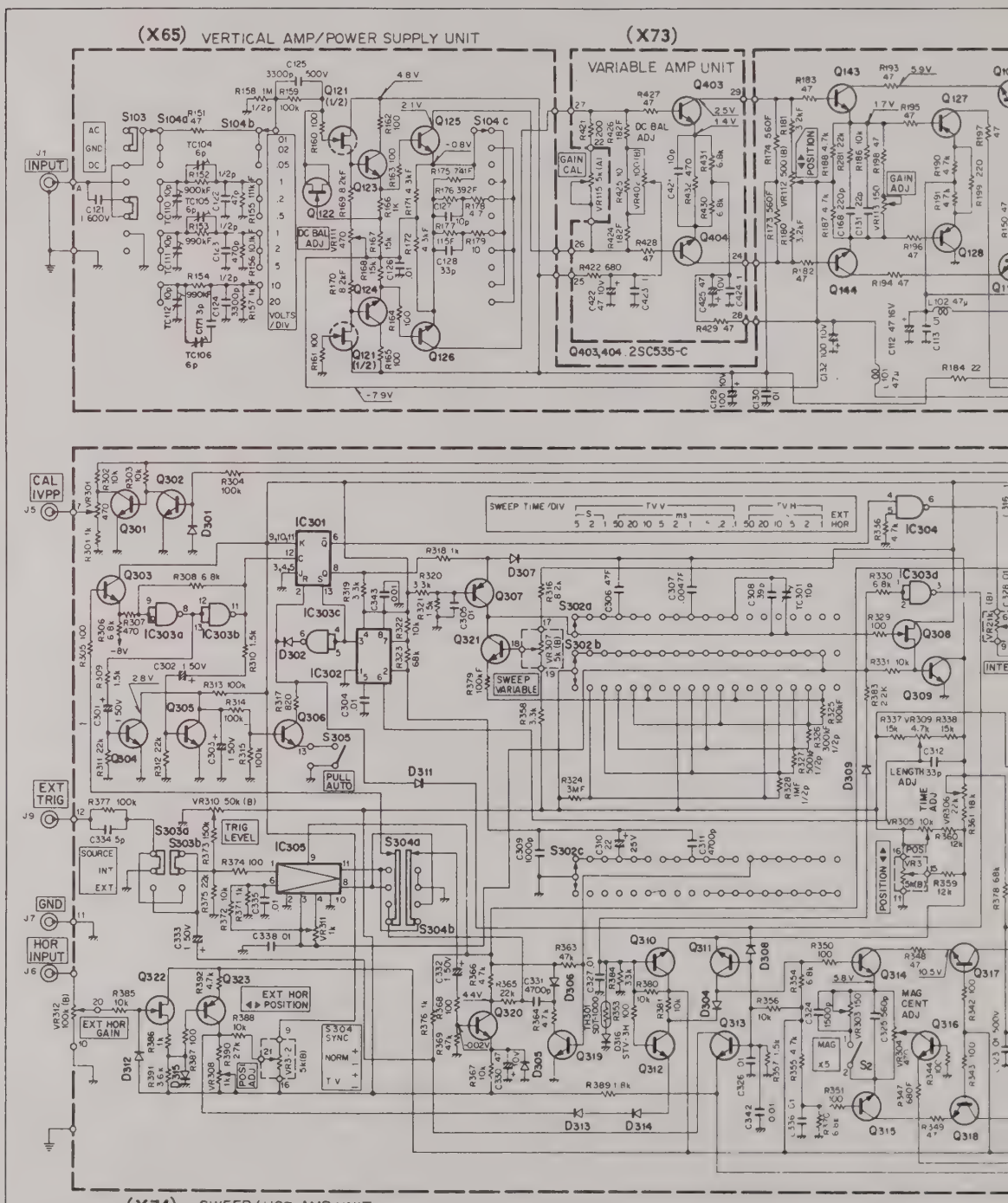
Pin No.	1**	2	3	4	5	6	7	8	9	10	11	12	13	14**
	-1.9KV	-1.95KV	-1.9KV	-1.4KV	75.6V	75.6V	75.6V	---	---	---	75.6V	60V	137V	1.9KV

NOTES:

1. All voltages measured with controls and switches set for normal operation, unless otherwise specified.
2. All voltages measured with a VTVM or equivalent meter from chassis ground. Supply voltage maintained at 117 volts AC, 60 Hz.

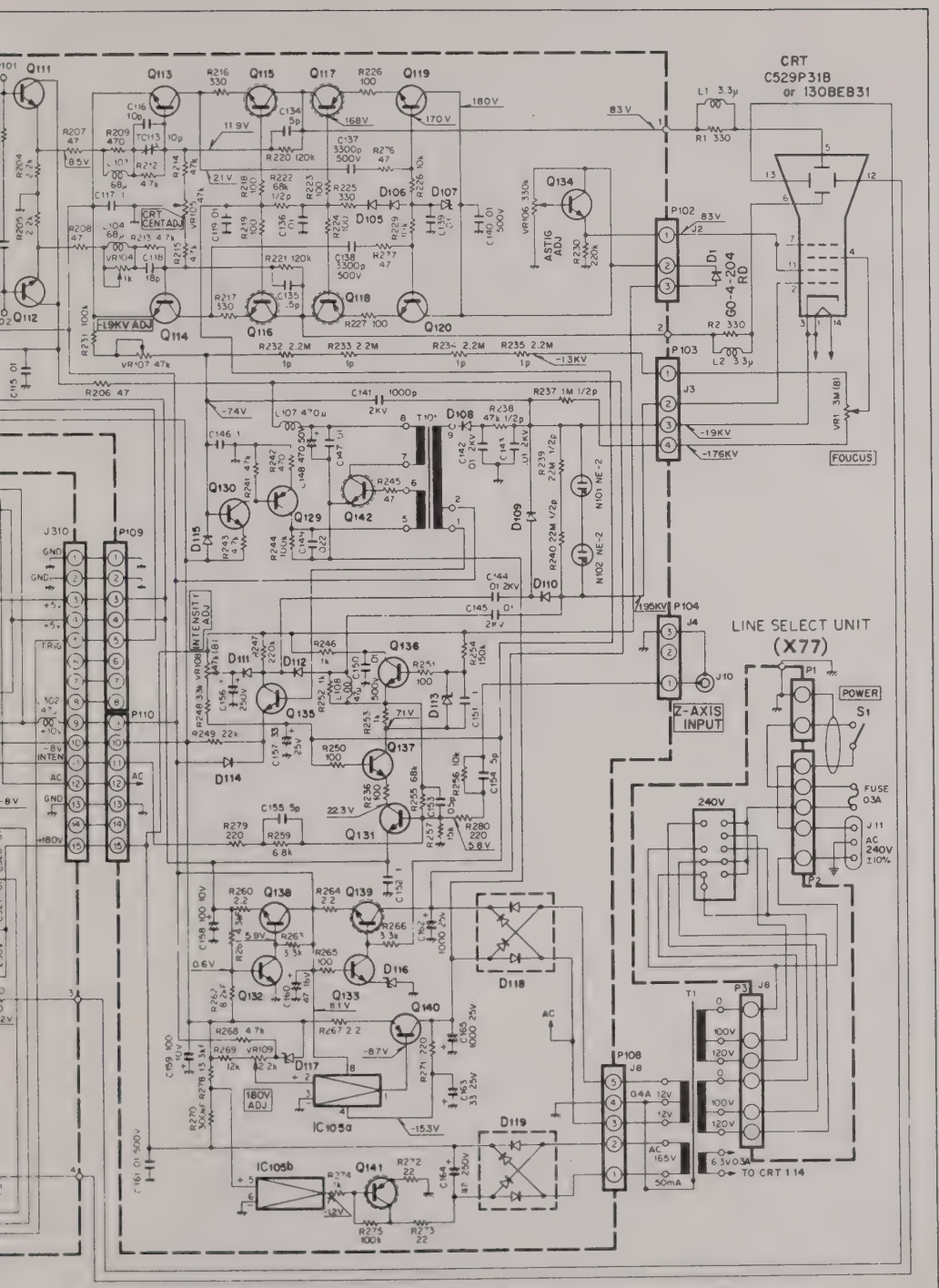
* Measured with SWEEP TIME/CM switch in .1 ms position.

** 6.3 volts AC measured between pins 1 and 14.



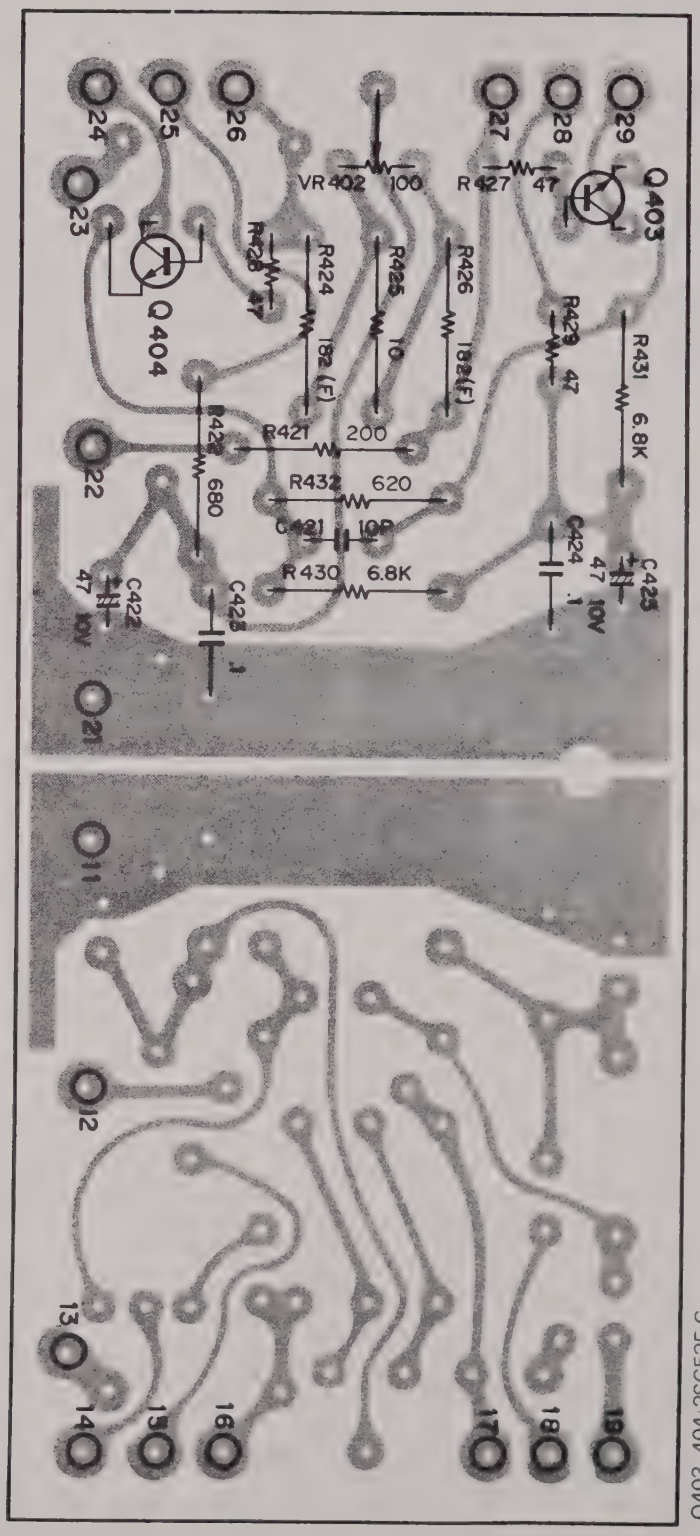
Q301~306, 309~316, 319~321:2SC945(P),
Q307, 323:2SA733(Q), Q308, 322:2SK30A(O),
Q317, 318:2SC1507, D301, 302, 304~306, 308,
309: 311~315:1S1555, D307:1S1587,
IC301:TD3472AP, IC302:RC555DN,
IC305:AN606, IC303, 304:TD3400AP

RESISTANSE VALUES IN Ω, 1/4W AND CAPACITANCE IN μF, F, UNLESS OTHERWISE SPE



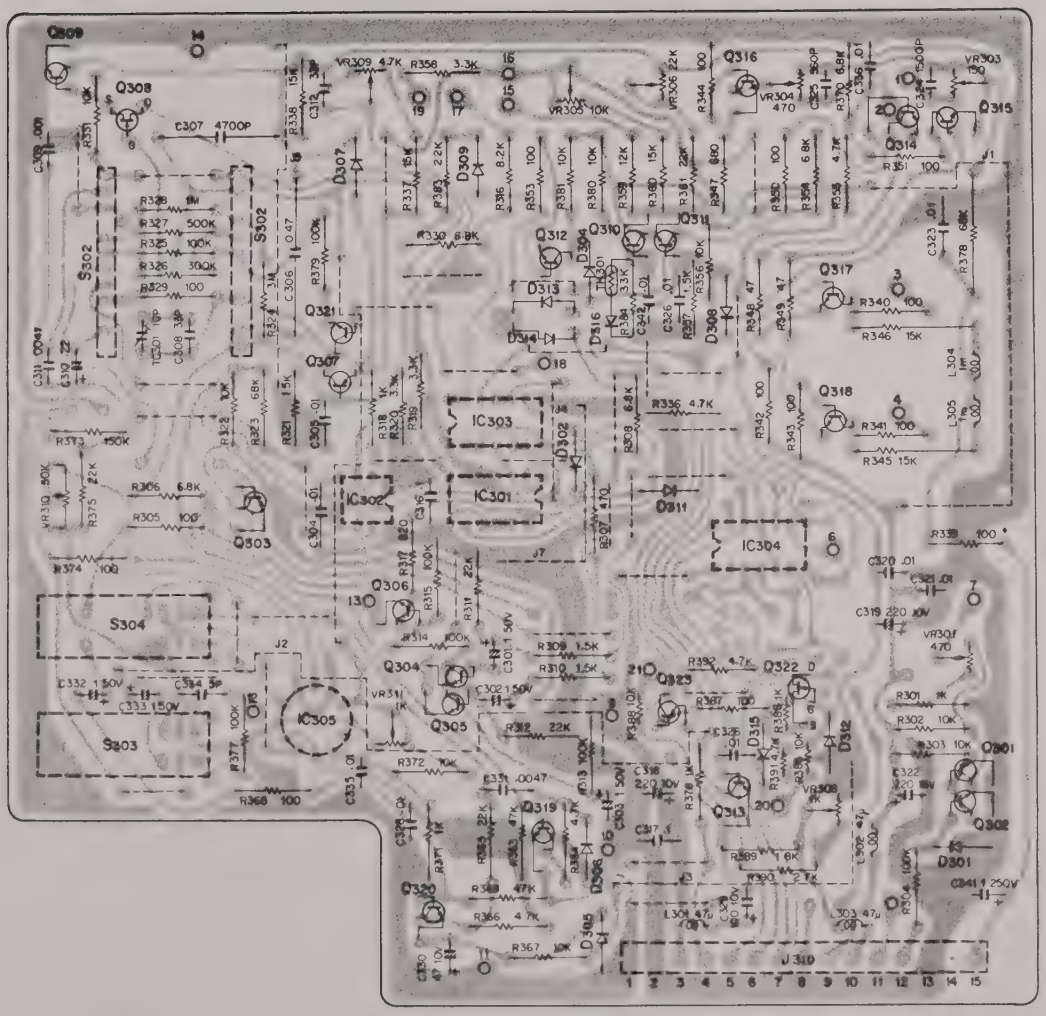
Q109~112, 119, 120, 123, 124, 130, 132, 133, 2SC945(P), Q113, 114, 125, 126, 131, 143, 144 : 2SC535(C), Q115, 116 : 2SC1628(Y)
Q117, 118 2SA818(Y), Q121 : E412S, Q122 : 2SK30A(O), Q127~129 : 2SA733(Q)
Q134~137 2SC983(Y), Q138 : 2SC1213(C), Q139 : 2SC1419(C), Q140 : 2SA755(C), Q141 : 2SB536(2) LM
Q142 : 2SD401(M), IC105 : RC4558T
D105, 106, 114, 115 : 1S1555, D107, 116 : WZ-100, D108 : Y16JA, D109~111 : W06C, D112 : 1S1705, D113 : WZ-050
D117 : WZ-090, D118, 119 : S1QB60

▼ VARIABLE AMP (X73)



Q403, 404: 2SC535-C

▼SWEEP CIRCUIT UNIT (X74)



Q301~306, 309~316, 319 ~321 :2SC945-P, Q307, 323:2SA733-Q, Q308, 322:2SK30A-O,
Q317, 318:2SC1507, IC301:TD3472AP, IC302:RC555DN, IC303, 304:TD3400AP,
IC305:AN606, D301, 302, 304~306, 308, 309, 311~315:1S1555, D307:1S1587,
D316:STV-3H, TH301:STD-1000

INSTRUCTION MANUAL

B+K PRECISION 1461

SOLID STATE, TRIGGERED SWEEP

OSCILLOSCOPE

B+K PRECISION

A Product of DYNASCAN CORPORATION · 6460 West Cortland Street · Chicago, Illinois 60635

INSTRUCTION MANUAL

FOR

B & K-PRECISION

MODEL 1461

SOLID STATE TRIGGERED SWEEP OSCILLOSCOPE

DYNASCAN CORPORATION
6460 West Cortland Street
Chicago, Illinois 60635

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WARRANTY 36

INTRODUCTION

The **B & K-Precision** Model 1461 Solid State Triggered Sweep Oscilloscope is a laboratory-quality, professional instrument for observing and measuring waveforms in electronic circuits. It performs all measurements made with conventional oscilloscopes, usually with greater stability and better resolution. In addition, it includes greater bandwidth, sweep speed, and sensitivity, plus extra features to provide the electronic sophistication required for servicing color television and other state-of-the-art devices.

FEATURES

FULLY SOLID STATE

Only the cathode ray tube uses a filament. All other stages use transistors, diodes, and FET's (field effect transistors). Among the advantages of solid state construction are:

- No stabilization warm-up time required.
- Low power drain.
- Dependability–reliability.
- Ruggedness.
- Light Weight.
- Compactness.

TRIGGERED SWEEP

The stability of waveform presentation is beyond comparison with non-triggered sweep oscilloscopes. The sweep remains at rest until triggered by the signal being observed to assure that they are always synchronized, even when the waveform is of varying period recurrence. Fully adjustable trigger threshold allows the desired portion of the waveform to be used for triggering.

LARGE SCREEN

The 130 mm (approximately 5.1 inches) diameter cathode ray tube provides easy-to-read displays.

CALIBRATED VOLTAGE SCALES

Accurate measurement of instantaneous voltages on 11 different ranges.

WIDE RANGE OF CALIBRATED SWEEP SPEEDS

Accurate time measurements on 18 different ranges. Sweep speeds of 1 μSEC/cm to 0.5 SEC/cm provide every speed necessary for viewing waveforms from DC to 10 MHz.

EXPANDED SCALE

A five time (5X) magnification of the horizontal sweep allows close-up examination of a portion of the waveform.

VECTORSCOPE

Vectorscope inputs and controls on the front panel, plus a vector overlay supplied with the oscilloscope provide a color demodulator display exactly as specified by color television manufacturers.

WIDE BANDWIDTH

DC to 10 MHz bandwidth and 35 nSEC rise time give distortion-free, high-resolution displays at high frequencies.

HIGH SENSITIVITY

Allows the low-capacitance, high-impedance, 10:1 attenuation probe to be used for virtually all measurements, thus offering less circuit loading.

TV SYNC

A built-in sync separator circuit is included specifically for viewing television signals. When using TV SYNC, television vertical sync pulses are automatically selected at sweep times of 0.5 SEC/cm to 0.1 mSEC/cm for viewing television frames. Television horizontal sync pulses are automatically selected at sweep times of 50 μSEC/cm to 1 μSEC/cm for viewing television lines.

CALIBRATION SOURCE

A built-in calibrated 1 volt peak-to-peak square wave permits checking and recalibration of the vertical amplifiers without additional equipment.

Z-AXIS INPUT

Intensity modulation capability included for time or frequency markers. Compatible with TTL logic; brightness increases in logic high state, decreases in logic low state.

SPECIFICATIONS

Fully regulated internal supplies; calibration accuracy applies over specified input voltage range.

VERTICAL AMPLIFIER

Deflection Factor	0.01 V/cm to 20 V/cm in 11 calibrated ranges in 1-2-5 sequence. Vernier provided for fine adjustment.
Calibration Accuracy	±5% on all ranges.
Frequency Response	DC: DC to 10 MHz (−3 dB). AC: 2 Hz to 10 MHz (−3 dB).
Risetime	35 nanoseconds.
Overshoot	3% or less at 100 kHz square wave display.
Ringing	3% or less at 100 kHz square wave display.
Input Resistance	1 megohm, ±5%.
Input Capacity	22 pF (±3 pF).
Max. Input Voltage	300 V (DC + AC peak) or 600 V p-p.

SWEEP CIRCUITS

Sweep System	Triggered and automatic. In automatic mode, sweep is obtained without input signal.
Sweep Time	1 μSEC/cm to 0.5 SEC/cm in 18 calibrated ranges, in 1-2-5 sequence. Vernier provided for fine adjustment.
Sweep Time Accuracy	±5%.
Sweep Magnification	Obtained by enlarging the above sweep 5 times from center. Maximum sweep speed becomes 0.2 μSEC/cm.
Horizontal Linearity	3% or less distortion. (5 μSEC/cm ~ 0.5 SEC/cm) 5% or less distortion (1 μSEC/cm ~ 2 μSEC/cm)

TRIGGERING

Source	INT and EXT (1 V p-p sensitivity).
Slope	Positive and negative, continuously variable level control; pull for AUTO.
Triggering Range	INT: 20 Hz to 10 MHz (min. 1 cm deflection as measured on cathode ray tube). EXT: DC ~ 10 MHz
TV Sync	Vertical and horizontal sync separator circuit provided so that any portion of complex TV waveform can be synchronized and expanded for viewing. Polarity for TV sync selected by SYNC switch. TVH (line) and TVV (frame) sync switched automatically by SWEEP TIME/CM switch. TVV (FRAME) = 0.5 SEC/cm to 0.1 mSEC/cm. TVH (LINE) = 50 μSEC/cm to 1 μSEC/cm.

HORIZONTAL AMPLIFIER (Horizontal Input through H INPUT jack).

Deflection Factor	150mV/cm or less.
Frequency Response	DC to 1 MHz (−3 dB).
Input Resistance	100 kΩ (nominal).
Input Capacity	35 pF or less.
Maximum Input Voltage	300 V (DC + AC peak) or 600 V p-p.
X-Y	Y (vertical) signal supplied to scope INPUT jack; X (horizontal) signal supplied to H INPUT jack.

CALIBRATION VOLTAGE

1 V p-p square wave (±5%) at line frequency.

INTENSITY MODULATION

Voltage	TTL logic compatible. High logic – increases brightness. Low logic – decreases brightness.
Input Resistance	10 kΩ (nominal).

POWER REQUIREMENTS

Input	117 or 230 VAC, ±10%, 50/60 Hz, 20 watts. (3-wire line cord, CSA approved for oscilloscopes.) Calibration accuracy applies over full input voltage range.

PROBES

Model No.	PR-20B, PR-24B, PR-31, PR-35.
Attenuation	Combination 10:1 and direct.
Input Impedances	10:1, 10 megohms, 18 pF. Direct, 1 megohm 120 pF.
Connector	BNC.
Tip	Spring-loaded, hook-on tip.

CONTROLS AND INDICATORS

1. Pilot lamp. Lights when oscilloscope is on.

2. **SWEEP TIME/CM** switch. Horizontal coarse sweep time selector. Selects calibrated sweep times of 1 μSEC/cm in 18 steps when VARIABLE/HOR GAIN control 3 is set to CAL. EXT position disables internal sweep generator and displays external horizontal input.

3. **VARIABLE/HOR GAIN** control. Fine sweep time adjustment (horizontal gain adjustment when SWEEP TIME/CM switch. 2 is in EXT H position). In the extreme clockwise position (CAL) the sweep time is calibrated.

4. **CAL** jack. Provides calibrated 1 Vp-p square wave output at line frequency (60 Hz).

5. ◄► **POSITION** control. Rotation adjusts horizontal position of trace. Push-pull switch selects 5X magnification when pulled out; normal when pushed in.

6. **TRIG LEVEL** control. Sync level adjustment determines point on waveform slope where sweep starts; (−) equals most negative point of triggering and (+) equals most positive point of triggering. Push-pull switch selects automatic triggering when pulled out (PULL AUTO). When automatic triggering, a sweep is generated even without an input signal.

7. **HOR INPUT** jack. Input terminal for external horizontal signal.

8. **SYNC** switch. Four-position lever switch with the following positions:

   SLOPE. The SLOPE positions are used for viewing all waveforms except television composite video signals.

   (+) Sweep is triggered on positive-going slope of waveform.

   (−) Sweep is triggered on negative-going slope of waveform.

   TV. In the TV positions, the sync pulses of a television composite video signal are used to trigger the sweep; the vertical sync pulses (frame) are automatically selected for sweep times of 0.5 SEC/cm to 0.1 mSEC/cm, and horizontal sync pulses (line) are automatically selected for sweep times of 50 μSEC/cm to 1 μSEC/cm.

   (+) Sweep is triggered on positive-going sync pulse.

   (−) Sweep is triggered on negative-going sync pulse.

9. **GND** terminal. Chassis ground.

10. **SOURCE** switch.

    INT: waveform being observed is used as sync trigger.

    EXT: signal at EXT TRIG jack **11** is used as sync trigger.

11. **EXT TRIG** jack. Input terminal for external sync.

12. ▲▼ **POSITION** control. Rotation adjusts vertical position of trace.

13. **INPUT** jack. Vertical input.

14. **AC-GND-DC** switch. Vertical input selector switch.

    AC position: blocks DC component of input signal.

    GND position: opens signal input path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing DC measurements.

    DC position: direct input of AC and DC component.

15. **VOLTS/CM** switch. Vertical attenuator. Coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 11 steps from .01 to 20 volts per cm when VARIABLE **16** is set to the CAL position.

16. **VARIABLE** control. Vertical attenuator adjustment. Fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.

17. **FOCUS** control.

18. **POWER OFF/INTENSITY** control. Fully counterclockwise turns off oscilloscope. Clockwise turns on oscilloscope and increases brightness of trace.

19. Cathode Ray Tube (CRT). This is the screen on which the waveforms are viewed.

20. Scale. Provides calibration marks for voltage and time measurements.

21. Vector overlay. Used for vectorscope applications. (Not illustrated.)

22. Probe. Combination 10:1 attenuation and direct measurement probe for vertical input. (Not illustrated.)

23. Combination feet and cord wrap (quantity of 4).

24. **INT MOD** jack. Intensity modulation (Z axis) input.

25. Power cord receptacle.

26. **DC BAL.** Balance adjustment for vertical amplifier.

27. CRT rotation adjustment.

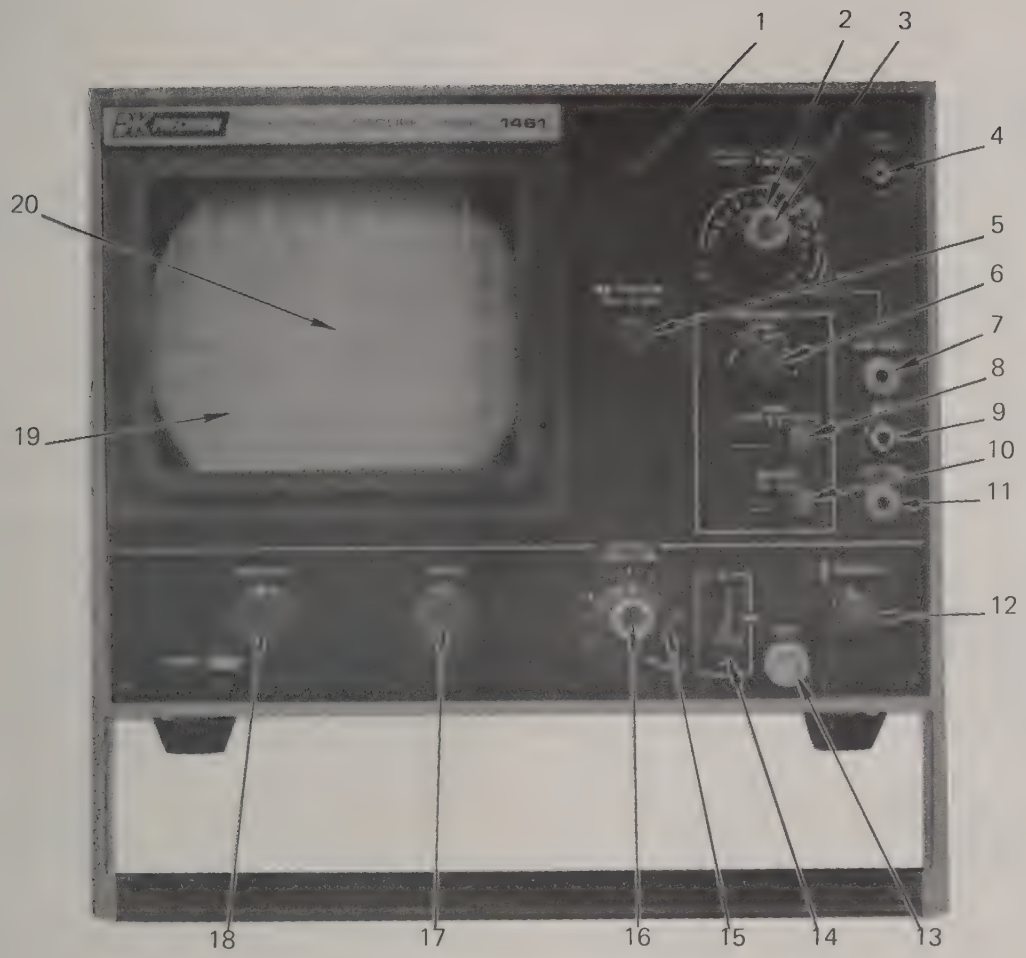


Fig. 1. Controls and indicators.

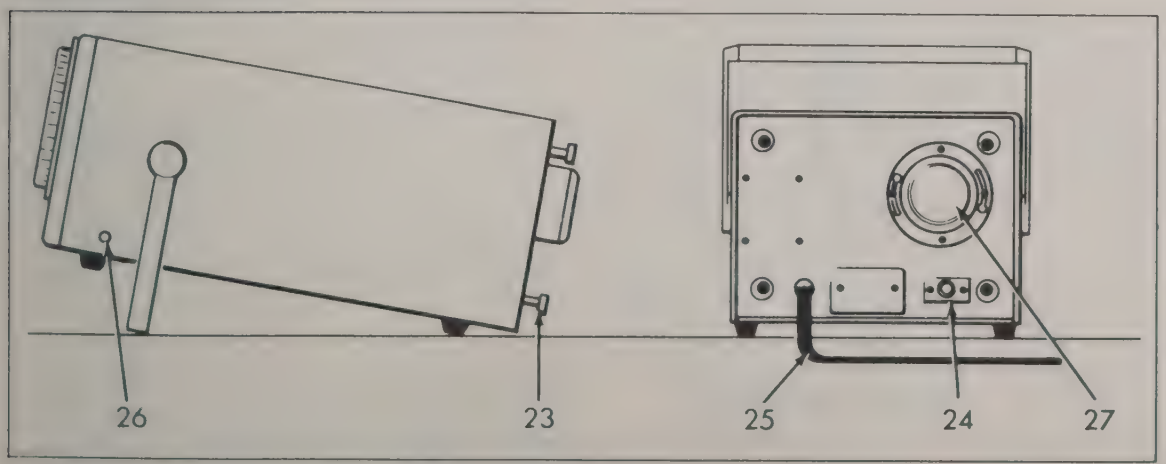


Fig. 2. Rear and side panel facilities.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. Reduce intensity or keep the spot in motion by causing it to sweep.

INITIAL STARTING PROCEDURE

1. Set the POWER OFF/INTENSITY control **18** to the OFF position (fully counterclockwise).
2. Connect the power cord to a 117 volt, 60 Hz AC outlet.
3. Set the ▲▼ POSITION control **12** and ◄► POSITION control **5** to the center of their ranges.
4. Pull TRIGGERING LEVEL control **6** to the AUTO position.
5. Set the AC-GND-DC switch **14** to the GND position.
6. Turn on the oscilloscope by rotating the POWER OFF/INTENSITY control **18** clockwise. It will "click" on and the pilot lamp will light.
7. Wait a few seconds for the cathode ray tube (CRT) to warm up. A trace should appear on the face of the CRT.
8. If no trace appears, increase (clockwise) the POWER OFF/INTENSITY control **18** setting until the trace is easily observed.
9. Adjust the FOCUS control **17** and POWER OFF/INTENSITY control **18** for the thinnest, sharpest trace.
10. Readjust the POSITION controls **5** and **12**, if necessary, to center the trace.
11. Check for proper adjustment of the astigmatism and DC balance controls and CRT positioning as instructed in the MAINTENANCE and CALIBRATION portion of this manual. These adjustments require checking only periodically.

The oscilloscope is now ready for making waveform measurements.

WAVEFORM OBSERVATION

1. Perform the steps of the initial starting procedure, then connect the probe cable to the INPUT receptacle **13**.
2. For all except low-amplitude waveforms, the probe is set for 10:1 attenuation. For low-amplitude waveforms (below 0.5 volt peak-to-peak), set the probe for DIRECT. See Fig. 3 for changing the probe from 10:1 to DIRECT, or vice versa. The probe has a 10 megohm input impedance with only 18pF shunt capacitance in the 10:1 position and 1 megohm with 35pF shunt capacitance in the DIRECT position. The higher input impedance (low capacity position) should be used when possible to decrease circuit loading.
3. Set the AC-GND-DC switch **14** to AC for measuring only the AC component (This is the normal position for most measurements and must be used if the point

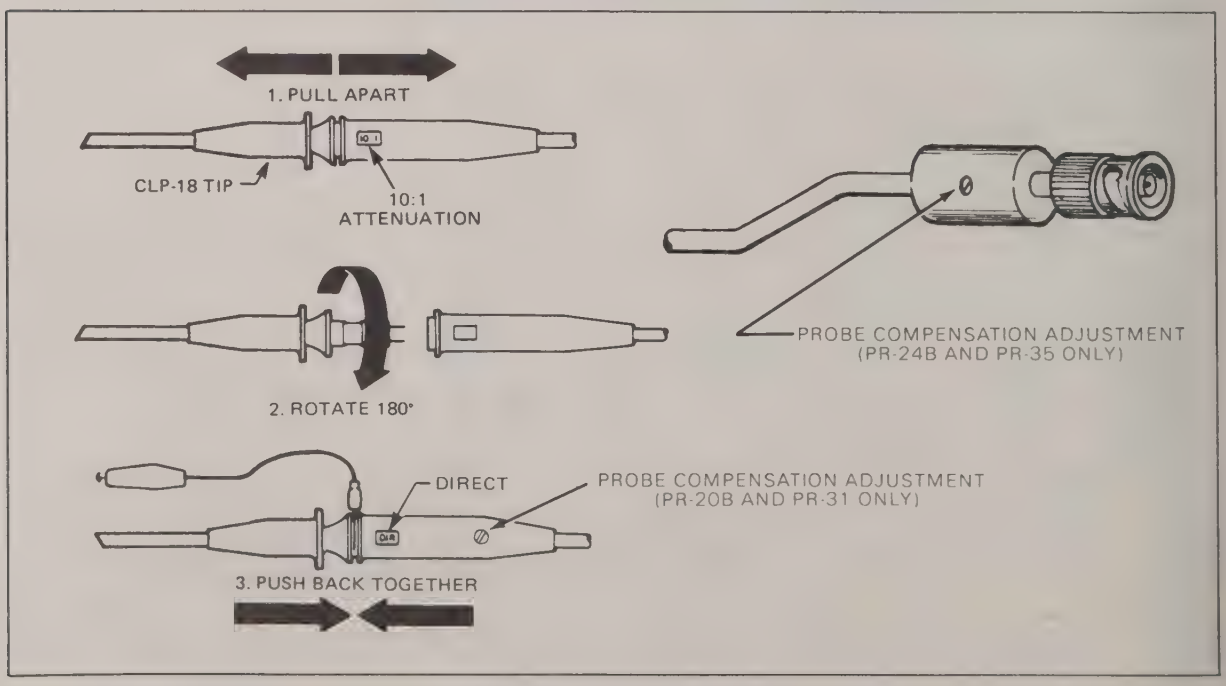


Fig. 3. Probe details.

being measured includes a large DC component.) Use the DC position for measuring both the AC component and the DC reference, and any time a very low-frequency waveform (below 5 Hz) is to be observed. The GND position is required only when a zero-signal ground reference is required, such as for DC voltage readings.

4. Connect the ground clip of the probe to chassis ground of the equipment under test. Connect the tip of the probe to the point in the circuit where the waveform is to be measured.

WARNING

1. If the equipment under test is a transformerless AC-powered item, use an isolation transformer to prevent dangerous electrical shock.

2. The peak-to-peak voltage at the point of measurement should not exceed 600 volts.

5. Set VOLTS/CM control **15** to a position that gives 2 cm to 6 cm (two to six large squares on the scale) vertical deflection.

   The display on the screen will probably be unsynchronized. The remaining steps are concerned with adjusting synchronization and sweep speed, which presents a stable display showing the desired number of waveforms. Any signal that produces at least 1 cm vertical deflection develops sufficient trigger signal to synchronize the sweep.

6. Set the SOURCE switch **10** to the INT (internal) position when the waveform being observed is also to be used to trigger the sweep. Most waveforms should be viewed with this switch in the INT position. When an external sync source is required, use the EXT position and a cable should be connected from the EXT TRIG jack **7** to the external sync source.

7. Set SYNC switch **8** to the TV(+) or TV(−) positions for observing television composite video waveforms or to the SLOPE(+) or SLOPE(−) positions for observing all other types of waveforms. Use the (+) position if the sweep is to be triggered by a positive-going wave, or the (−) position if the sweep is to be triggered by a negative-going wave. If the type of waveform is unknown, the SLOPE(+) position may be used.

8. Readjust TRIGGERING LEVEL control **6** to obtain a synchronized display without jitter. As a starting point, the control may be pushed in and rotated to any point that will produce a sweep, which is usually somewhere in the center portion of its range. The trace will disappear if there is inadequate signal to trigger the sweep, such as when measuring DC or extremely low amplitude waveforms. If no sweep can be obtained, pull the control out (PULL AUTO) for automatic triggering.

9. Set the SWEEP TIME/CM control **2** and VARIABLE/HOR GAIN control **3** for the desired number of waveforms. These controls may be set for viewing only a portion of a waveform, but the trace becomes progressively dimmer as a proportionately smaller portion is displayed. This is because the writing speed increases but the sweep repetition rate does not change.

NOTE

When using very fast sweep speed at low repetition rates, the operator may wish to operate with the intensity control toward maximum. Under these conditions, a retrace "pip" may appear at the extreme left of the trace. This does not in any way affect the oscilloscope operation and may be disregarded.

10. After obtaining the desired number of waveforms, as in step 9, it is sometimes desirable to make a final adjustment of the TRIGGERING LEVEL control **6**. The (−) direction selects the most negative point on the waveform at which sweep triggering will occur and the (+) direction selects the most positive point on the waveform at which sweep triggering will occur. The control may be adjusted to start the sweep on any desired portion of the waveform.

11. For a close-up view of a portion of the waveform, pull outward on the ◄► POSITION control **5**. This expands the sweep by a factor of five (5X magnification) and displays only the center portion of the sweep. To view a portion of the left of center, turn the ◄► POSITION control **5** clockwise, and to view portion to the right of center, turn the control counterclockwise. Push inward on the control to return the sweep to the normal, non-magnified condition.

CALIBRATED VOLTAGE MEASUREMENT

Peak voltages, peak-to-peak voltages, DC voltages and voltages of a specific portion of a complex waveform are easily and accurately measured on this oscilloscope.

1. Adjust controls as previously instructed to display the waveform to be measured.

2. Be sure the vertical VARIABLE control **16** is set fully clockwise to the CAL position.

3. Set the VOLTS/CM control **15** for the largest vertical deflection possible without exceeding the limits of the vertical scale.

4. Read the amount of vertical deflection (in cm) from the scale. The ▲▼ POSITION control **12** may be readjusted to shift the reference point for easier scale reading if desired. When measuring a DC voltage, adjust the ▲▼ POSITION control **12** to a convenient reference with the AC-GND-DC switch **14** in the GND position, then note the amount the trace is deflected when the switch is placed in the DC position. The trace deflects upward for a positive voltage input and downward for a negative voltage input.

NOTE

For an accurate display of high-frequency waveforms above 5 MHz, it is important that the probe be used in the 10:1 position to reduce circuit loading and that the oscilloscope controls be set so that the height of the pattern does not exceed 4 centimeters and that the trace be centered vertically.

5. Calculate the voltage reading as follows:

   Multiply the vertical deflection (in cm) by the VOLTS/CM control **15** setting (see example in Fig. 4). Don't forget that the voltage reading displayed on the oscilloscope is only 1/10th the actual voltage being measured when the probe is set for 10:1 attenuation. The actual voltage is displayed when the probe is set for DIRECT measurement.

6. Calibration accuracy of the oscilloscope may be occasionally checked by observing the 1 volt peak-to-peak square wave signal available at the CAL jack **4**. This calibrated source should read exactly 0 volt peak-to-peak. If a need for recalibration is indicated, see the MAINTENANCE AND CALIBRATION section of the manual for complete procedures.

CALIBRATED TIME MEASUREMENT

Pulse width waveform periods, circuits delays and all other waveform time durations are easily and accurately measured on this oscilloscope. Calibrated time measurements from 5 seconds down to .2 μSEC are possible. At low sweep speeds, the entire waveform is not visible at one time. However, the bright spot can be seen moving from left to right across the screen which makes the beginning and ending points of the measurement easy to spot.

1. Adjust controls as previously described for a stable display of the desired waveform.

2. Be sure the VARIABLE/HOR GAIN control **3** is fully clockwise to the CAL position.

3. Set the SWEEP TIME/CM control **2** for the largest possible display of the waveform segment to be measured, usually one cycle.

4. If necessary, readjust the TRIGGERING LEVEL control **6** for the most stable display.

5. Read the amount of horizontal deflection (in cm) between the points of measurement. The ◄► POSITION control **5** may be readjusted to align one of the measurement points with a vertical scale marker for easier reading.

6. Calculate the time duration as follows:

   Multiply the horizontal deflection (in cm) by the SWEEP TIME/CM control **2** setting (see example in Fig. 5). Remember, when the 5X magnification is used, the results must be divided by 5 to obtain the actual time duration.

7. Time measurements often require external sync. This is especially true when measuring delays. The sweep is

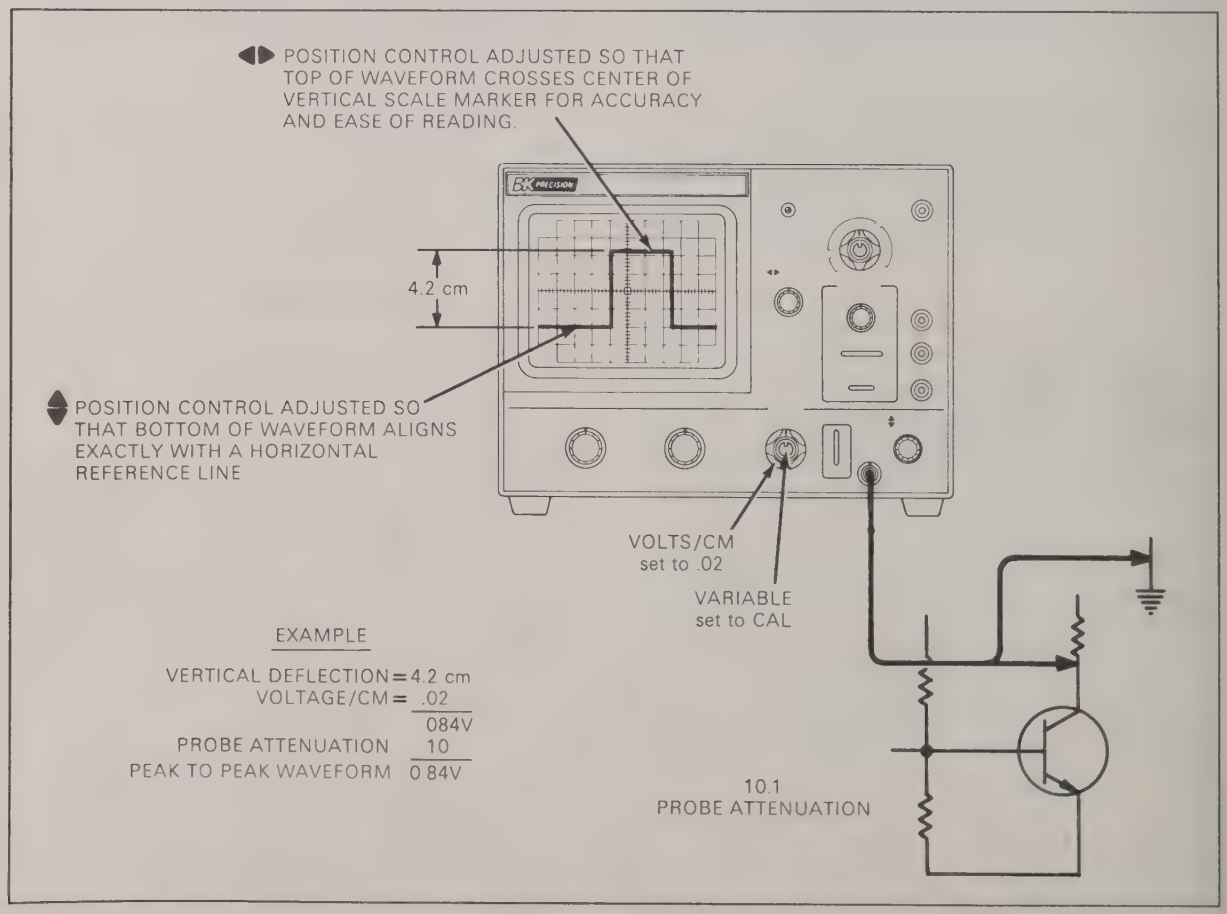

◄► POSITION CONTROL ADJUSTED SO THAT TOP OF WAVEFORM CROSSES CENTER OF VERTICAL SCALE MARKER FOR ACCURACY AND EASE OF READING.
4.2 cm
▲ POSITION CONTROL ADJUSTED SO THAT BOTTOM OF WAVEFORM ALIGNS EXACTLY WITH A HORIZONTAL REFERENCE LINE
VOLTS/CM set to .02
VARIABLE set to CAL
EXAMPLE
VERTICAL DEFLECTION = 4.2 cm
VOLTAGE/CM = .02
084V
PROBE ATTENUATION 10
PEAK TO PEAK WAVEFORM 0 84V
10.1 PROBE ATTENUATION

Fig. 4. Typical voltage measurement.

started by a sync signal from one circuit and the waveform measured in a subsequent circuit. This allows measurement of the delay between the sync pulse and the subsequent waveform. To perform such measurements using external sync, use the following steps:

a. Set the SOURCE switch **10** to the EXT position.

b. Connect a lead from the EXT TRIG jack **11** to the source of the sync signal. Use a short shielded cable.

c. Set the SYNC switch **8** to SLOPE (+) or (–) for the proper polarity of the sync signal.

d. Readjust the TRIGGERING LEVEL control **6** if necessary, for a stable waveform.

e. Set the SWEEP TIME/CM control **2** as for other time measurements. Do not set it to the EXT H position. This position is for external horizontal deflection, not external sync.

f. If measuring a delay, measure the time from the start of the sweep to the start of the waveform.

EXTERNAL HORIZONTAL INPUT (X-Y OPERATION)

For some measurements, an *external* horizontal deflection signal is required. This is also referred to as an X-Y measurement, where the Y input provides vertical deflection and the X input provides horizontal deflection. The horizontal input may be a sinusoidal wave, such as used for phase measurement, or an external sweep voltage. This input voltage must be about 100 millivolts per cm of deflection (usually 1 volt or more peak-to-peak will provide satisfactory results). To use an external horizontal input, use the following procedure.

1. Set the SWEEP TIME/CM control **2** to the EXT H position.

2. Connect the external horizontal signal source through a cable to the HOR INPUT jack **11**.

3. Adjust the amount of horizontal deflection with the VARIABLE/HOR GAIN control **3**, which adjusts the gain to the horizontal amplifier.

4. All sync controls are disconnected and have no effect.

Z-AXIS INPUT

The trace displayed on the screen may be intensity-modulated (Z-axis input) where frequency or time-scale markers are required. A 5 volt peak-to-peak or greater signal applied at the INT MOD (intensity modulation) jack **24** on the rear of the oscilloscope will provide alternate brightness and blanking of the trace. (See Fig. 6.) This comparatively low voltage sensitivity permits Z-axis operation from TTL logic circuits.

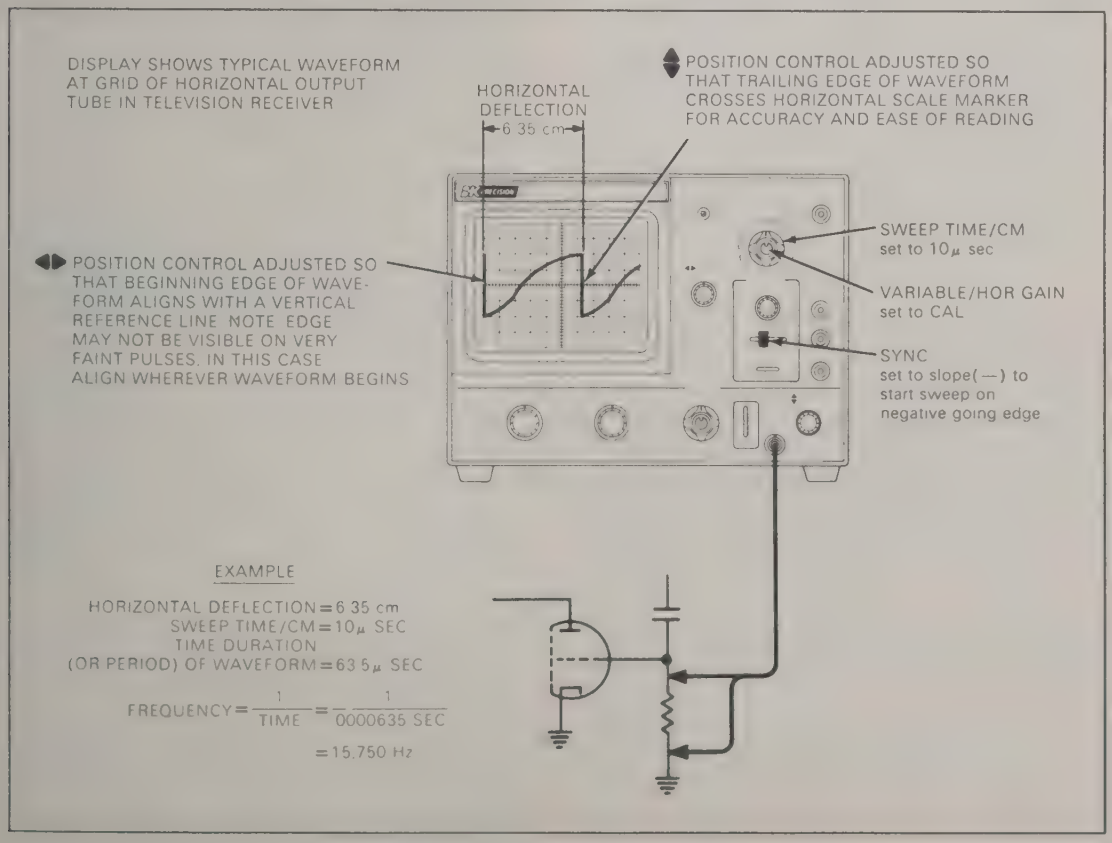

DISPLAY SHOWS TYPICAL WAVEFORM AT GRID OF HORIZONTAL OUTPUT TUBE IN TELEVISION RECEIVER
HORIZONTAL DEFLECTION
6.35 cm
POSITION CONTROL ADJUSTED SO THAT TRAILING EDGE OF WAVEFORM CROSSES HORIZONTAL SCALE MARKER FOR ACCURACY AND EASE OF READING
POSITION CONTROL ADJUSTED SO THAT BEGINNING EDGE OF WAVEFORM ALIGNS WITH A VERTICAL REFERENCE LINE. NOTE EDGE MAY NOT BE VISIBLE ON VERY FAINT PULSES. IN THIS CASE ALIGN WHEREVER WAVEFORM BEGINS
SWEEP TIME/CM set to 10μ sec
VARIABLE/HOR GAIN set to CAL
SYNC set to slope(—) to start sweep on negative going edge
EXAMPLE
HORIZONTAL DEFLECTION = 6.35 cm
SWEEP TIME/CM = 10μ SEC
TIME DURATION (OR PERIOD) OF WAVEFORM = 63.5μ SEC
FREQUENCY = 1/TIME = 1/0.0000635 SEC
= 15,750 Hz

Fig. 5. Typical time measurement.

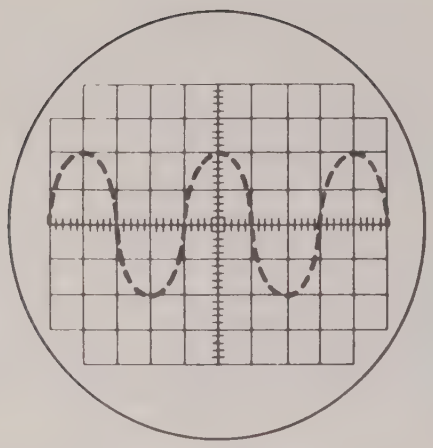


Fig. 6. Oscilloscope trace with Z-axis input.

APPLICATIONS

TELEVISION SERVICING

A triggered sweep oscilloscope is advantageous in servicing and aligning television receivers. This oscilloscope also includes several features that were incorporated to make television servicing easier and more comprehensive. These features include:

- SWEEP TIME/CM control automatically selects vertical sync at sweep speeds appropriate for viewing frames and horizontal sync at sweep speeds appropriate for viewing lines.
- Vector overlay for color demodulator checks.
- Wide bandwidth for high resolution video and pulse presentation.

SIGNAL TRACING AND PEAK-TO-PEAK VOLTAGE READINGS

For general troubleshooting and isolation of troubles in television receivers (or almost any other electronic equipment for that matter), the oscilloscope is an indispensible instrument. It provides a visual display of absence or presence of normal signals. This method (signal tracing) may be used to trace a signal path. As measurements proceed along the signal path, a point may be found where the signal disappears. When this happens, the source of trouble has been located.

However, the oscilloscope shows much more than the mere presence or absence of signal. It provides a peak-to-peak voltage measurement of the signal.

The cause of poor performance can often be located by making such peak-to-peak voltage measurements. The schematic diagram or accompanying service data on the equipment being serviced usually includes waveform pictures. These waveform pictures include the required sweep time and the normal peak-to-peak voltage. Compare the peak-to-peak voltage readings on the oscilloscope with those shown on the waveform pictures. Any abnormal reading should be followed by additional readings in the suspected circuits until the trouble is isolated to as small an area as possible. The procedures for making peak-to-peak voltage measurements are given earlier in the CALIBRATED VOLTAGE MEASUREMENT paragraph.

COMPOSITE VIDEO WAVEFORM ANALYSIS

Probably the most important waveform in television servicing is the composite waveform consisting of the video signal, the blanking pedestals and the sync pulses. Figs. 7 and 8 show typical oscilloscope traces when observing composite video signals synchronized with horizontal sync pulses and vertical sync pulses. Composite video signals can be observed at various circuits of the television receiver to determine whether circuits are performing normally. Knowledge of waveform makeup, the appearance of a normal waveform, and the causes of various abnormal waveforms help the technician locate and correct many problems. The technician should study such waveforms in a television receiver known to be in good operating condition, noting the waveform at various points in the video amplifier.

To set up the oscilloscope for viewing television composite video waveforms, use the following procedure:

1. Tune the television set to a local channel.
2. Set the SWEEP TIME/CM switch to the 10 μS/cm position for observing TV horizontal lines or 2 mSEC/cm for observing TV vertical frames.
3. Set the SYNC switch to the TV+ position.
4. Pull the TRIGGERING LEVEL control for automatic sync.
5. Set the DC-GND-AC switch to the AC position.
6. Connect a probe cable to the INPUT jack. Connect the ground clip of the probe to the television set chassis. With the probe set for 10:1 attenuation, connect the tip of the probe to the video detector output of the television set.
7. Set the VOLTS/CM switch for the largest vertical deflection possible without going off-scale.
8. If necessary, rotate the TRIGGERING LEVEL control to a position that provides a synchronized display.
9. Adjust the sweep time VARIABLE control for two horizontal lines or two vertical frames of composite video display.
10. If the sync and blanking pulses of the displayed video signals are positive, set the SYNC switch to the TV+ position; if the sync and blanking pulses are negative, use the TV- position.
11. Push in the TRIGGERING LEVEL control and rotate to a position that provides a well-synchronized display.
12. Adjust the INTENSITY and FOCUS controls for the desired brightness and best focus.

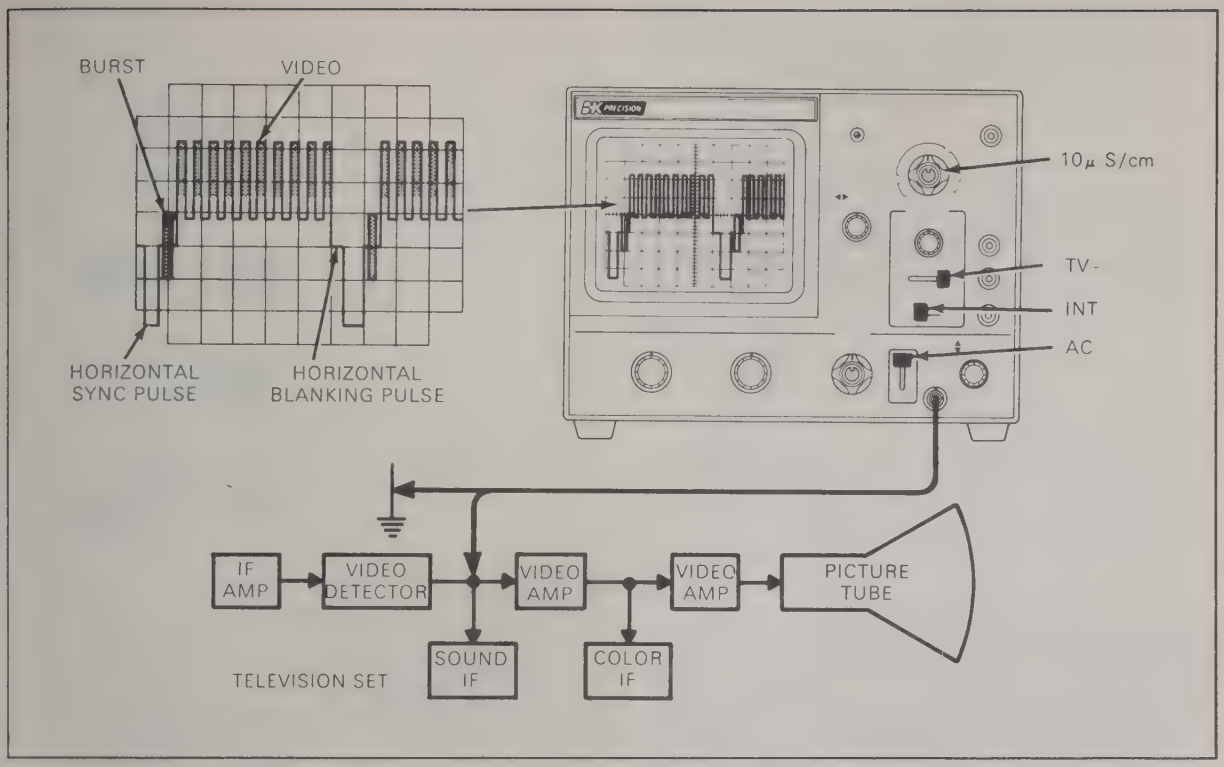


Fig. 7. Set-up for viewing horizontal lines of the composite video signal.

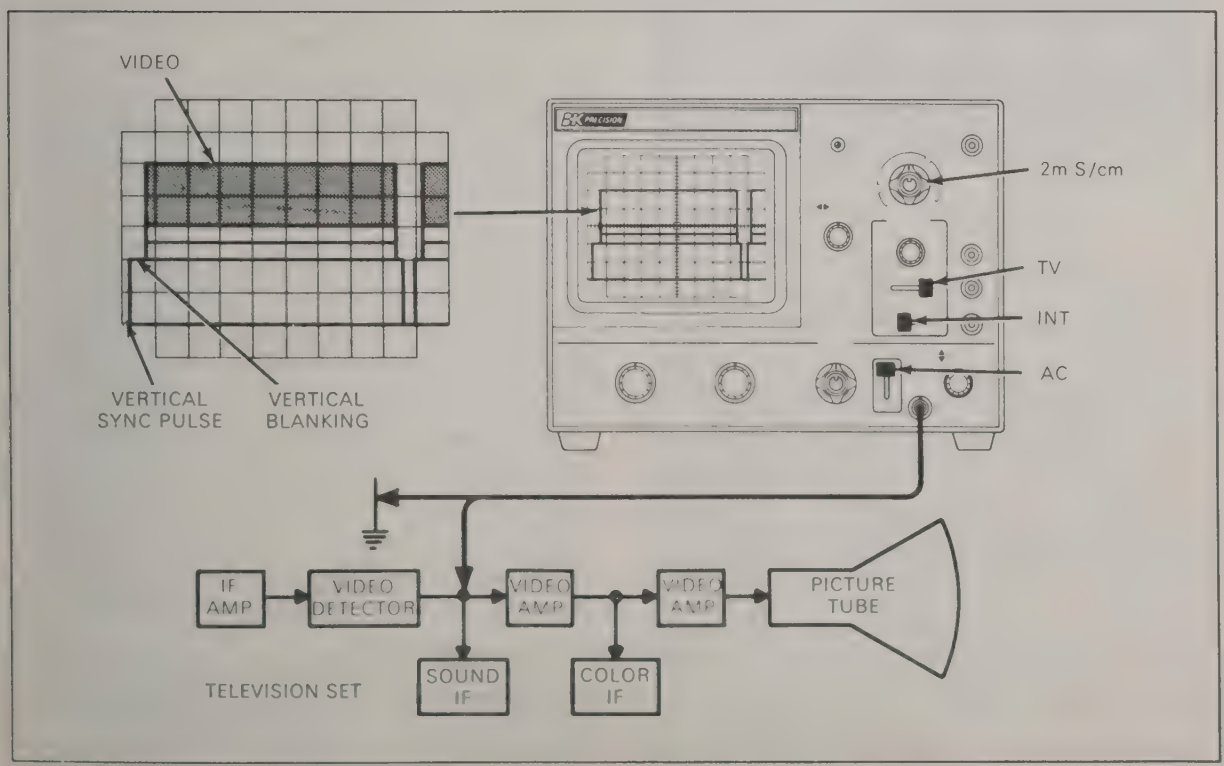


Fig. 8. Set-up for viewing vertical fields of the composite video signal.

13. To view a specific portion of the waveform, such as the color burst, pull outward on the ◄► POSITION control for 5X magnification. Rotate the same control left or right to select the desired portion of the waveform to be viewed.

14. Composite video waveforms may be checked at other points on the video circuits by moving the probe tip to those points and changing the VOLTS/CM control setting as required to keep the display within the limits of the scale, and by readjusting the TRIGGERING LEVEL control to maintain stabilization. The polarity of the observed waveform may be reversed when moving from one monitoring point to another; therefore, it may be necessary to reverse the polarity of the SYNC.

SYNC PULSE ANALYSIS

The IF amplifier response of a television receiver can be evaluated to some extent by careful observation of the horizontal sync pulse waveform. The appearance of the sync waveform is affected by the IF amplifier bandpass characteristics. Some typical waveform symptoms and their relations to IF amplifier response are indicated in Fig. 9. Sync pulse waveform distortions produced by positive or negative limiting in IF overload conditions are shown in Fig. 10.

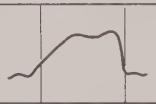
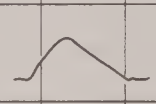
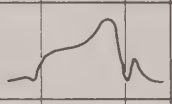
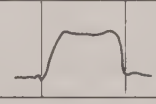
CIRCUIT DEFECT	HORIZONTAL PULSE DISTORTION	OVERALL RECEIVER FREQUENCY RESPONSE	EFFECT ON PICTURE
Normal Circuit			Picture Normal
Loss of high frequency response			Loss of picture detail
Excessive high frequency response non-linear phase shift			Fine vertical black and white striations following a sharp change in picture shading
Loss of low frequency response			Change in shading of large picture areas, smeared picture

Fig. 9. Analysis of sync pulse distortion.

VITS (VERTICAL INTERVAL TEST SIGNAL)

Most network television signals contain a built-in test signal (the VITS) that can be a very valuable tool in troubleshooting and servicing television sets. This VITS can localize trouble to the antenna, tuner, IF or video sections and shows when realignment may be required. The following procedures show how to analyze and interpret oscilloscope displays of the VITS.

The VITS is transmitted during the vertical blanking interval. On the television set, it can be seen as a bright white line above the top of the picture, when the vertical linearity or height is adjusted to view the vertical blanking interval (on TV sets with internal retrace blanking circuits, the blanking circuit must be disabled to see the VITS).

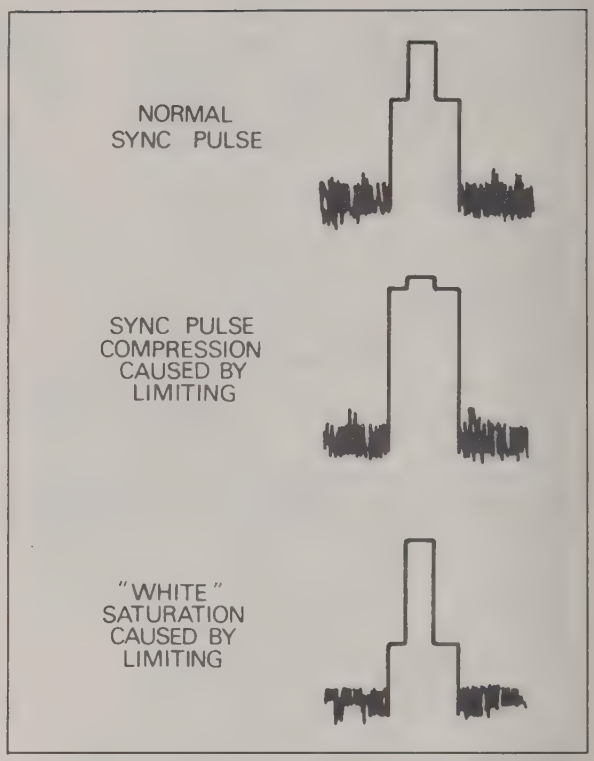


Fig. 10. Sync pulse waveforms.

The transmitted VITS is a precision sequence of specific frequency, amplitude, and waveshape as shown in Figs. 11 and 12. The television networks use the precision signals for adjustment and checking of network transmission equipment, but the technician can use them to evaluate television set performance. The first line of field #1 (line 17) begins with a "flag" of white video, followed by sine wave frequencies of 0.5 MHz, 1.5 MHz, 2 MHz, 3 MHz, 3.6 MHz (3.58 MHz), and 4.2 MHz. This sequence of frequencies is called the "multi-burst". The first line of field #2 (line 279) also contains an identical multi-burst. This multi-burst portion of the VITS is the portion that can be most valuable to the technician. The second line of field #1 and the second line of field #2 (lines 18 and 280) together contain the sine-squared pulse, window pulse and the staircase of 3.58 MHz bursts at progressively lighter shading. These are valuable to the network, but have less value to the technician. As seen on the television screen, field #1 is interlaced with field #2 so that line 17 is followed by line 279 and line 18 is followed by line 280. The entire VITS appears at the bottom of the vertical blanking pulse and just before the first line of video.

Each of the multi-burst frequencies is transmitted at equal amplitude. By observing the comparative amplitudes of these frequencies after the signal is processed through the television receiver, the frequency response of the set is checked.

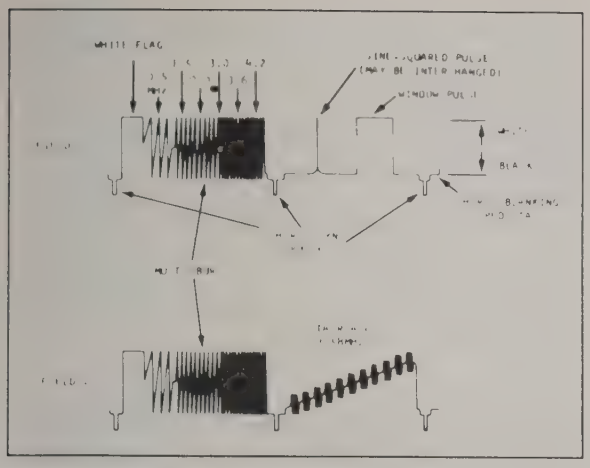


Fig. 11. VITS signal, fields 1 and 2.

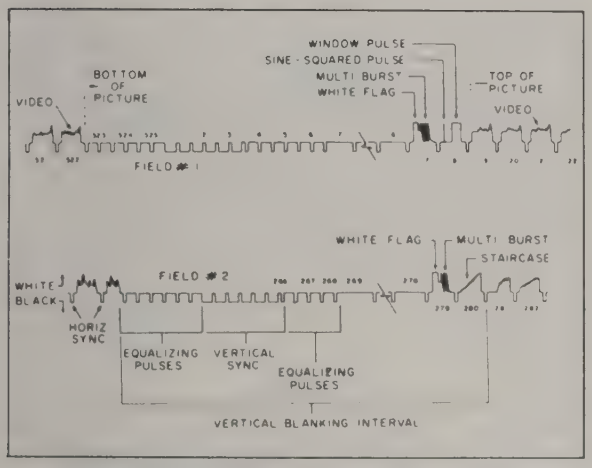


Fig. 12. Vertical blanking interval, showing VITS information.

Set up the oscilloscope as follows to view the VITS:

1. Connect the probe (set at 10:1) to the output of the video detector or other desired test point in the video section of the television set.

2. If the television set has a vertical retrace blanking circuit, bypass this circuit during the measurement.

3. Set up the oscilloscope for television vertical as previously described. Two vertical frames will be visible.

4. Place the VARIABLE/HOR. GAIN control in the CAL position.

5. Reduce sweep time to .1 millisecond per centimeter (.1 ms/CM) with the SWEEP TIME/CM switch. This expands the display by increasing the sweep speed. The VITS information will appear to the right on the expanded waveform display.

6. Further expand the sweep with the 5X magnification (pull outward on the ◄► POSITION control). Rotate the ◄► POSITION control in a counterclockwise direction, moving the trace to the left, until the expanded VITS appears.

NOTE

The brightness level of the signal display will be reduced because, although the repetition rate is only 60 Hz (a 16,000 μSEC period), the writing speed is 20 μSEC/cm magnified five times).

7. The waveform should be similar to that shown in Fig. 13. For the oscilloscope display, each vertical sync pulse starts a new sweep. This causes line 17 and line 279 (multi-burst) to be superimposed, as are lines 18 and 280. The multi-burst signals are identical which reinforces the trace. However, lines 18 and 280 are not identical and both signals are superimposed over each other. This should present no problem, since the multi-burst is normally the signal of interest.

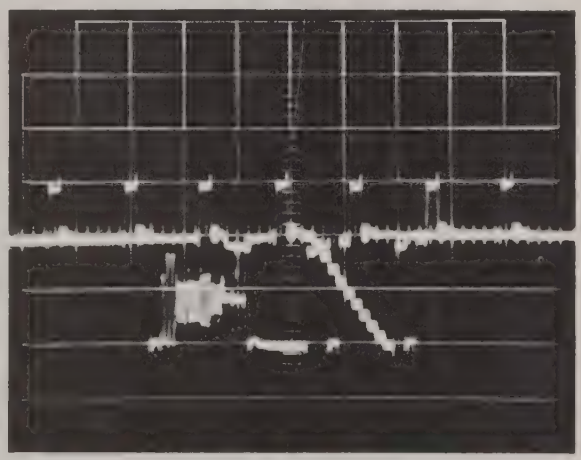


Fig. 13. Oscilloscope presentation of VITS information.

Now to analyze the waveform. All frequencies of the multi-burst are transmitted at the same level, but should not be equally coupled through the receiver due to its response curve. Fig. 14 shows the desired response for a good color television receiver, identifying each frequency of the multi-burst and showing the allowable amount of attenuation for each. Remember that -6 dB equals half the reference voltage (the 2.0 MHz modulation should be used for reference).

To localize trouble, start by observing the VITS at the video detector. This will localize trouble to a point either before or after the detector. If the multi-burst is normal at the detector, check the VITS on other channels. If some channels look okay but others do not, you probably have tuner or antenna-system troubles. Don't overlook the chance of the antenna system causing "holes" or tilted response on some channels. If the VITS is abnormal at the video detector on all channels, the trouble is probably in the IF amplifier stages.

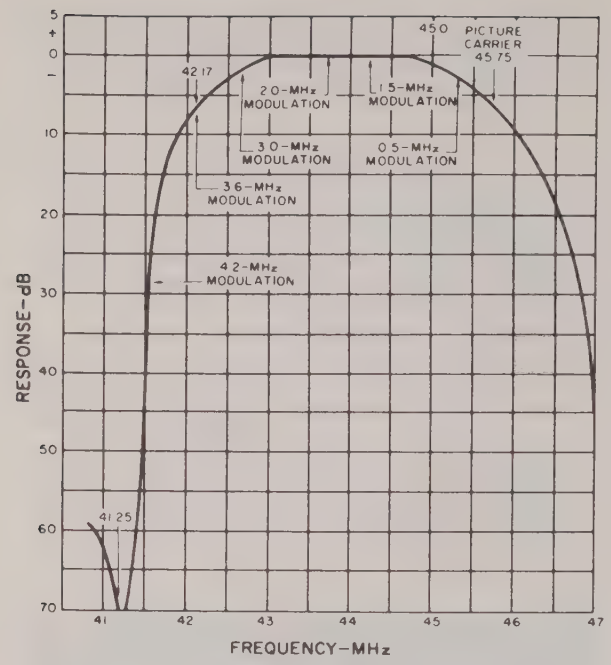


Fig. 14. Color TV IF amplifier response curve.

As another example, let us assume that we have a set on the bench with a very poor picture. Our oscilloscope shows the VITS at the video detector to be about normal except that the burst at 2.0 MHz is low compared to the bursts on either side. This suggests an IF trap is detuned into the passband, chopping out frequencies about 2 MHz below the picture carrier frequency. Switch to another channel carrying VITS. If the same thing is seen, then our reasoning is right, and the IF amplifier requires realignment. If the poor response at 2 MHz is not seen on other channels, maybe an FM trap at the tuner input is misadjusted, causing a bite on only one channel. Other traps at the input of the set could similarly be misadjusted or faulty.

If the VITS response at the detector output is normal for all channels, the trouble will be in the video amplifier. Look for open peaking coils, off-value resistors, solder bridges across foil patterns, etc.

VECTORSCOPE OPERATION

Performance testing and adjustment of the color circuits in color television receivers is simplified by using the vectorscope operation of the oscilloscope. The additional equipment needed is a color bar generator. The **B & K-Precision** color bar generators are ideally suited.

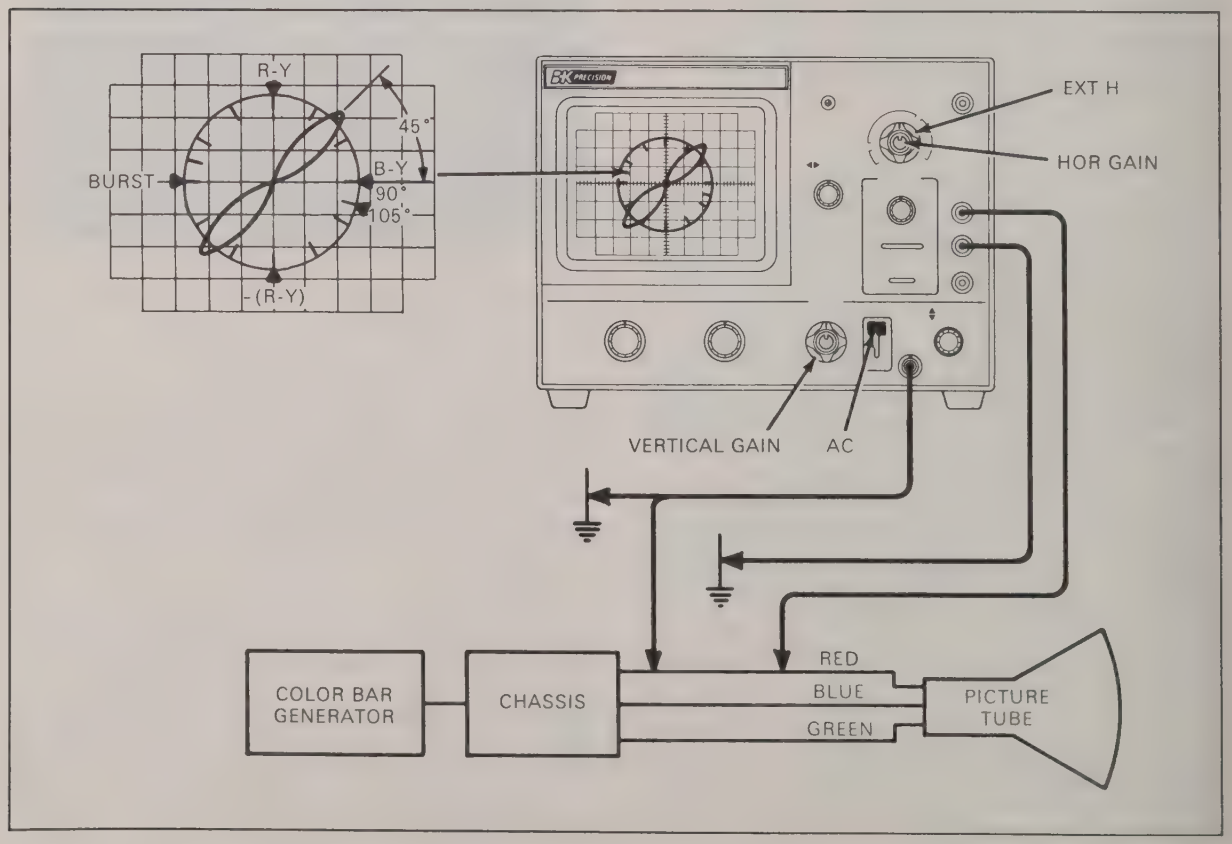


Fig. 15. Equalizing horizontal and vertical gain for vectorscope operation.

First the horizontal and vertical gain of the oscilloscope must be equalized (see Fig. 15).

1. Attach vector overlay to scope. Lift off bezel, insert overlay and re-attach bezel. (Refer to MAINTENANCE AND CALIBRATION Section for graticule removal.)

2. Connect the color bar generator to the television set and tune in the color bar pattern.

3. Adjust the television set's hue and brilliance controls to mid-range.

4. Set the SWEEP TIME/CM control to the EXT H position.

5. Connect the probe cable to the INPUT receptacle and another coaxial or shielded test lead to the HOR INPUT jack. Connect both probes to the driven element of the red gun, usually the grid. If the cathode is the driven element, then connect to the cathode. (The driven element is the element to which the output signal of the color amplifier is applied.)

6. Adjust the vertical and horizontal gain controls to obtain a compressed 45° pattern that approximately fills the vector overlay. The oscilloscope is now set up for vectorscope operation.

7. For vectorscope presentation, merely move the horizontal probe to the driven element of the blue gun. The color vector pattern is the same type as given by the television set manufacturer. Figs. 16A through D show typical displays obtained for sets using 105° systems and 90° systems with either grid drive or cathode drive.

NOTE

If the picture tube uses cathode drive, the burst will appear on the right side of the screen. Just rotate the vector overlay 180° so the BURST label is on the right side. The color bars will then align with the vector overlay.

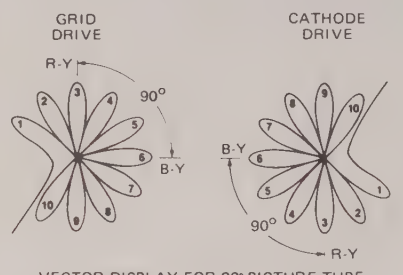
The vector display provides a very quick measurement of the functions of the demodulators in a color TV set. The serviceman should familiarize himself with the effect on the pattern produced by the color controls. He should observe that the color amplitude control will vary the size of the petals but not their position. The hue control changes the position of the petals but not their amplitude. Lastly, 105° sets will have a more elliptical pattern than 90° sets. The table below lists some common troubles and their effect on the pattern.

The vector display can be used to check the range of the color set's hue control. It should be possible to rotate the R-Y petal about the vertical axis. At the center of the hue control the R-Y petal should be vertical. If it is not, locate the CHROMA reference oscillator. In most sets this oscillator is transformer coupled to the demodulators.

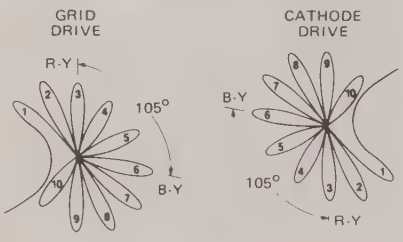
A slight touch up of this transformer is all that is necessary to bring the R-Y petal to a vertical position. Do not attempt to make any adjustments on the chroma bandpass amplifiers. This amplifier is aligned by a sweep generator and cannot in general be aligned by just a vector display.

If the set has adjustable demodulators the vector display can also be used for demodulator alignment. Follow the manufacturer's alignment procedure to locate the proper coils and instead of counting bars, simply adjust for the correct angle between R-Y and B-Y.

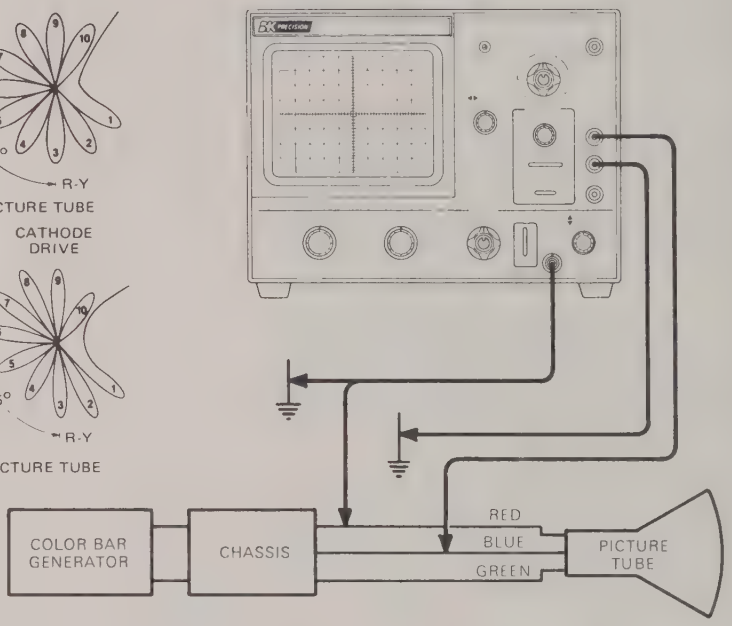
NOTES



VECTOR DISPLAY FOR 90° PICTURE TUBE



VECTOR DISPLAYS FOR 105° PICTURE TUBE



TROUBLE	EFFECT ON PATTERN	EFFECT ON T.V. PICTURE
Loss of color sync	Petals of pattern will rotate	Varying colors
Overloading of color amplifiers	Petals are crushed or flattened	Color distortion
Color amplifiers unbalanced or weak	Flower pattern very elliptical	Color distortion
Lack of range of hue control	R-Y petal cannot be made to be vertical	Hue control won't adjust fleshtones
Demodulator out of alignment	Angle between R-Y petal and B-Y petal not to manufacturer's specification (90° or 105° General Specification).	Wrong colors

Fig. 16. Vectorscope operation and patterns.

INTRODUCTION

Alignment of tuners, the video IF strip, and chroma circuits in television receivers requires a high quality oscilloscope, such as this instrument. The additional pieces of test equipment required are sweep generators for video sweep, IF sweep and RF sweep, marker generators, DC bias supplies and a VTVM. The sweep generator method of alignment displays a bandpass response curve on the screen of the oscilloscope of the type always shown in theory books and in the television set manufacturer's alignment instructions (typical response curves are shown in Fig. 17).

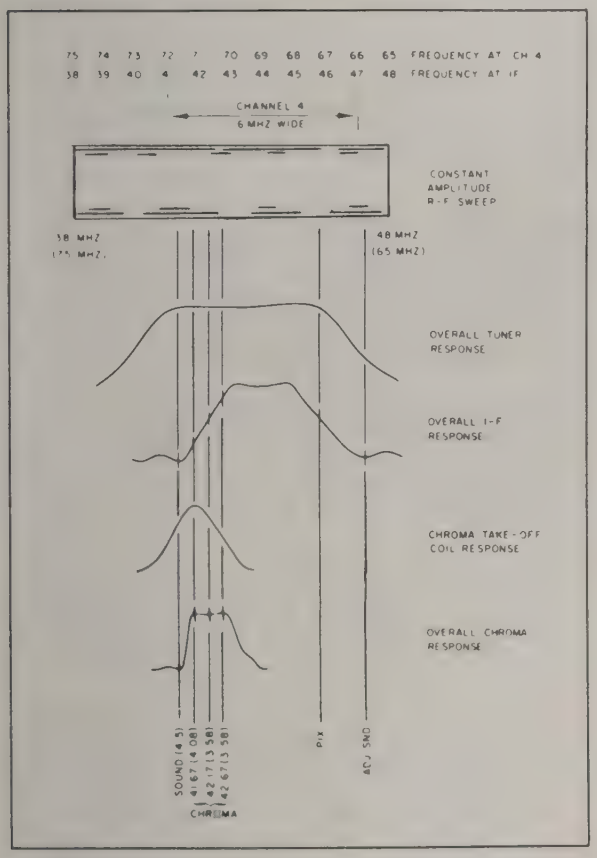


Fig. 17. TV response curves obtained by sweep-frequency technique.

The ideal instruments for television alignment are this oscilloscope and the **B & K-Precision** Sweep/Marker Generator. The **B & K-Precision** Sweep/Marker Generator provides all necessary sweep ranges, markers and DC bias voltages, all from one instrument. The simplified operating procedure and calibrated accuracy of the instrument results in precision alignment.

For complete alignment instructions of each particular television set, follow the manufacturer's instructions. However, the following general set-up instructions tell how to use the oscilloscope for sweep-frequency alignment.

In this manual, only the proper use of the oscilloscope in television is emphasized. Proper use of the sweep generator and other equipment required for alignment should be provided in the instruction manuals for those instruments.

NOTE

For a comprehensive analysis of television alignment, we recommend the instruction manual for the **B & K-Precision** Model 415 Sweep/Marker Generator. This "handbook for television alignment" includes not only the procedures for using the instrument, but all the how and why answers about television alignment in general. Even if you use other sweep generators, this book provides valuable procedures, insights and tips that will make alignment easier and more professional. The many illustrations and easy-to-understand step-by-step approach qualify it as the "how to align" textbook. Copies are available from your **B & K-Precision** distributor or the factory.

IMPORTANCE OF SWEEP ALIGNMENT

The most rapid way to determine the overall condition of the tuner, IF and chroma portions of the television receiver is to provide a constant-amplitude signal which sweeps through the entire bandwidth of a given television channel at a controlled, repetitive rate. As this signal is processed through the tuned portions of the receiver, it is shaped by the gain and bandpass properties of the various sections. Because the signal is channeled from one series of tuned circuits to another it is important that each section has the proper characteristics. If the signal is demodulated at certain points and the envelope observed, the gain and bandwidth properties up to that point can be determined.

Fig. 17 shows the sweep signal with basic response curves of the tuner IF amplifiers and chroma bandpass circuits below it. The bandwidths shown are approximately to scale. These outlines are similar to the curves that would be obtained if the outputs of the various sections of the TV receiver were demodulated and the curve observed on an oscilloscope. Because of the relative bandwidths, the tuner response is least critical.

Some reference frequencies are identified to show the importance of proper alignment. Notice that the chroma frequencies are on the slope of the IF response curve. This area is the most critical because improper IF alignment in this area will affect the amplitude and shape of the chroma response curve and this in turn affects color picture quality.

Notice that the chroma information is located on a constant-amplitude portion of the transmitted television spectrum. Notice that the relative amplitudes of the chroma information are modified by passing through the tuned circuits of the television receiver tuner and IF amplifiers. This is shown by reference to the overall IF response curve. Notice that the signal information at the upper end of the chroma frequency range (4.08 MHz) is reduced in amplitude with respect to the signal level at the lower end of the chroma frequency range (3.08 MHz). To compensate for this frequency-versus-amplitude characteristic of the overall IF response curve, a chroma takeoff coil is used between the IF output and the bandpass amplifier of the

chroma portion of the receiver. The chroma takeoff coil is tuned to the upper end of the chroma frequency range, usually 4.08 MHz and provides a response as shown in Fig. 17. This compensates for the amplitude-versus-frequency characteristic of the chroma portion of the overall IF response curve. The result of combining the response of the IF curve and the response of the chroma takeoff coil is to produce a flat overall response in the chroma frequency range (3.08 MHz to 4.08 MHz). The resultant signal is then applied to the bandpass amplifier which has the response indicated by the overall chroma response curve.

Alignment of the chroma takeoff coil is sometimes specified as a separate step in manufacturer's test procedures. In other procedures, adjustment of the chroma takeoff coil is performed together with the adjustment of the bandpass transformer.

SWEEP ALIGNMENT METHODS

The best method of checking alignment and determining which stages require alignment is to inject an RF sweep frequency signal at the tuner antenna terminals. The AGC bias line must be clamped by application of bias or grounding the AGC line. The outputs of the IF and chroma circuits are then observed on an oscilloscope and compared to the manufacturer's recommended response curves.

The technician can then decide which portions of the receiver require alignment. For example, if the IF response is satisfactory but the chromas response is not, then the problem is between the video detector output of the IF strip and the output of the bandpass amplifier. If the IF response and the chroma response are poor then it is most likely that the IF requires touch-up, particularly if the response is poor on the slope affecting chroma response.

The RF portion of the tuner seldom creates an alignment problem because the passband is so much greater than that of the IF section; however, the mixer output circuit, which is located on the tuner, may require attention. This is part of the tuned matching network between the tuner and the first IF stage. A separate prealignment procedure is given for the link circuits by some manufacturers.

Once the deficient portion of the receiver is determined, an alignment check of that section can be performed. The alignment procedures vary with manufacturers. Some suggest signal combinations at the tuner antenna terminals which can generate IF and video sweep frequencies in the receiver so that overall alignment can be done by selecting the right combination of input signals. One way of doing this is to first connect an RF sweep generator for IF alignment. After this is complete, the picture carrier frequency for the channel being used is selected and this is modulated by a video sweep signal. (This is the VSM, or video sweep modulation method.) This video sweep modulation is demodulated at the video detector of the TV receiver and applied to the chroma bandpass circuits for the alignment of these stages.

Other manufacturers recommend an IF sweep frequency injected at the mixer grid (or base, if transistorized) for IF alignment. The IF picture carrier frequency (45.75 MHz) is then modulated with a video sweep voltage (VSM again). As before this is detected at the video detector of the TV receiver and the recovered sweep voltage is used for the chroma circuit alignment.

Another method is to first video-sweep align the chroma circuits directly. The IF is then aligned and then video sweep modulation of the IF pix frequency (45.75 MHz) is used to check the combined effect on the chroma response of IF alignment and chroma alignment. Usually a touch-up of the chroma circuits is done to obtain the desired final overall chroma response.

In conjunction with IF alignment practically all manufacturers recommend pretuning IF traps by injecting spot frequencies into the IF (usually at a specified tuner test point). Other procedures outline a prealignment of all tuned circuits in the IF before sweep alignment procedures.

In all cases the manufacturer's method is the best for his particular receiver and the manufacturer's service manual is preferred for alignment. SAMS PHOTOFACT procedures are also reliable and in most cases repeat the manufacturer's procedure. If complete realignment of an apparently deficient receiver does not restore the required response, the technician must then consider that a component failure has occurred and must employ standard troubleshooting procedures.

TUNER ALIGNMENT (Refer to Fig. 18)

1. Connect the output of the sweep generator to the antenna terminals of the television set. Adjust the sweep generator to sweep one of the TV channels.

2. Tune the TV set to the same channel.

3. Connect the ground clip of the oscilloscope probe directly to the tuner shield to minimize hum pickup. Connect the vertical probe (set to DIRECT) to the tuner test point. The tuner test point is normally the grid of the mixer tube or equivalent, where a demodulated signal is present.

4. Set the vertical controls for maximum sensitivity and operate the sweep generator at low level to avoid overloading the television receiver, which would distort the response curve and provide an erroneous picture of alignment on the oscilloscope screen.

5. The oscilloscope sweep and sweep generator must be in exact synchronization and phase with each other for proper presentation of the response curve. This is easily accomplished for sinusoidal or sawtooth sweep by setting the oscilloscope for external horizontal input and connecting the horizontal sweep voltage from the sweep generator to the external horizontal input terminals on the oscilloscope.

6. Select the marker generator frequencies required to measure the upper and lower response of the tuner.

7. The tuner response curve is now displayed on the oscilloscope. See the manufacturer's instructions for the response curve specifications and the necessary adjustments for realignment.

IF ALIGNMENT (Refer to Fig. 19)

1. Connect the output of the sweep generator to the signal injection point of the mixer. Adjust the sweep generator to sweep the IF frequency band. (If the tuner has been properly aligned, RF sweep may be applied at the antenna terminals.)

2. Synchronize the oscilloscope sweep with the sweep generator as previously described in the TUNER ALIGNMENT procedure.

3. Connect the ground clip of the oscilloscope vertical probe to the television set chassis.

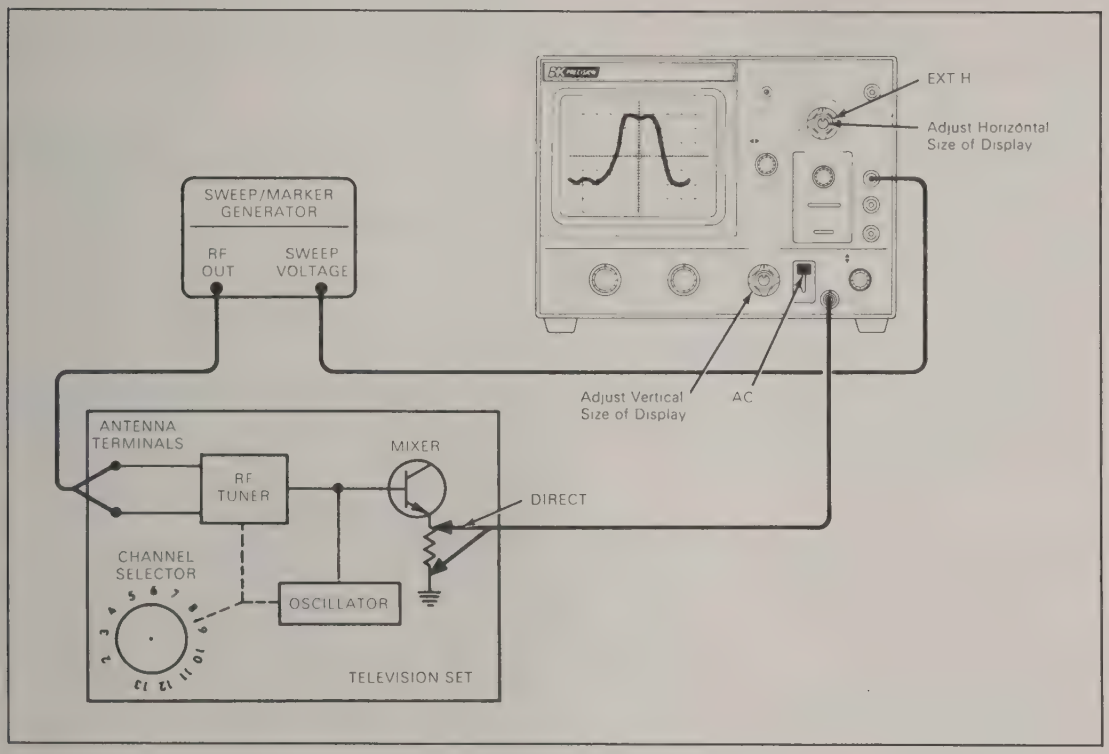


Fig. 18. Typical tuner alignment set-up.

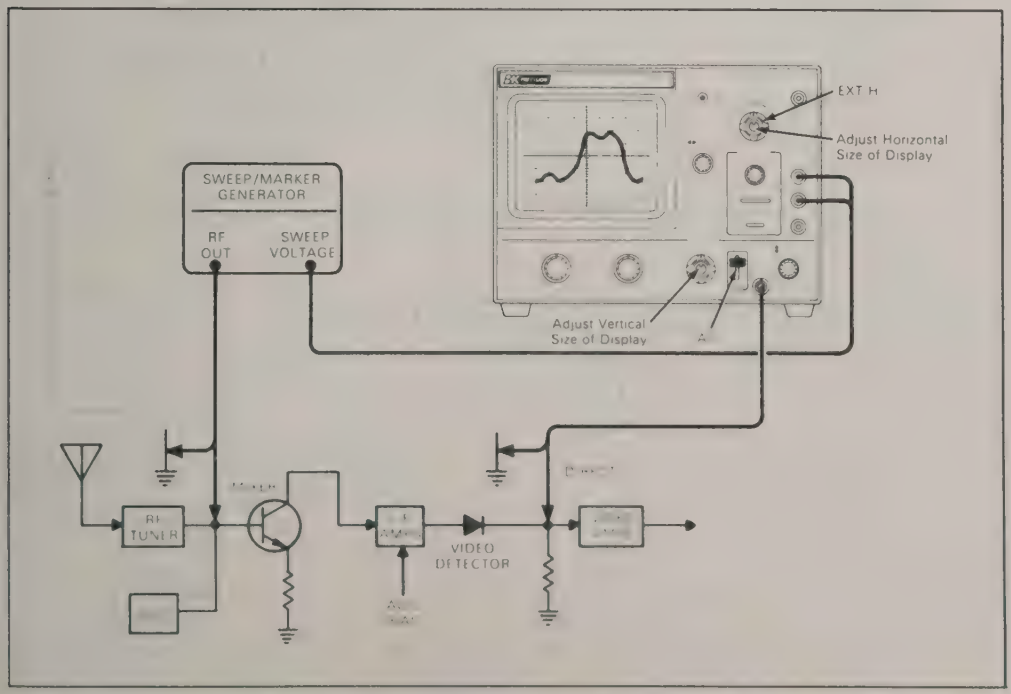


Fig. 19. Typical IF alignment set-up.

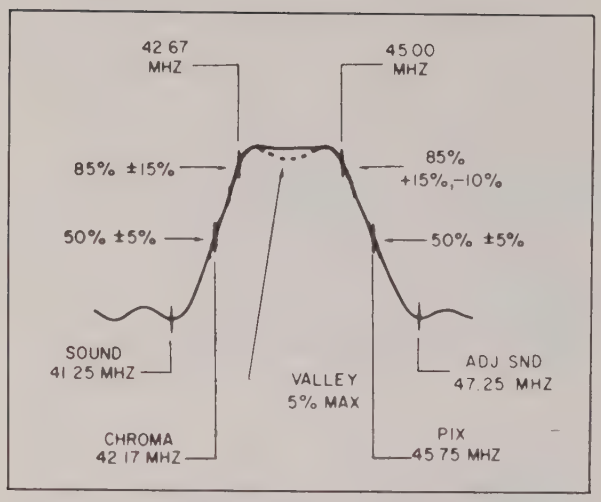


Fig. 20. Typical IF response curve, showing tolerance ranges of response levels.

4. Connect the vertical probe of the oscilloscope to the video detector output.

5. Set the vertical gain controls (VOLTS/CM and VARIABLE) for suitable viewing of the response curve.

6. Keep the sweep generator output level low to prevent overloading. Follow the manufacturer's recommendations on disabling AGC.

7. Select the marker generator frequencies required to check the critical frequencies of interest (see Fig. 20). A sweep and marker generator capable of displaying all the markers simultaneously, such as the **B & K-Precision** Model 415, is a big advantage.

8. Follow the manufacturer's instructions for evaluating the response curve and making the alignment.

CHROMA ALIGNMENT (Refer to Fig. 21)

The IF alignment must be satisfactorily completed before starting this chroma alignment procedure. If direct injection of video sweep is used, rather than the IF sweep injection specified herein, the response curve is altered

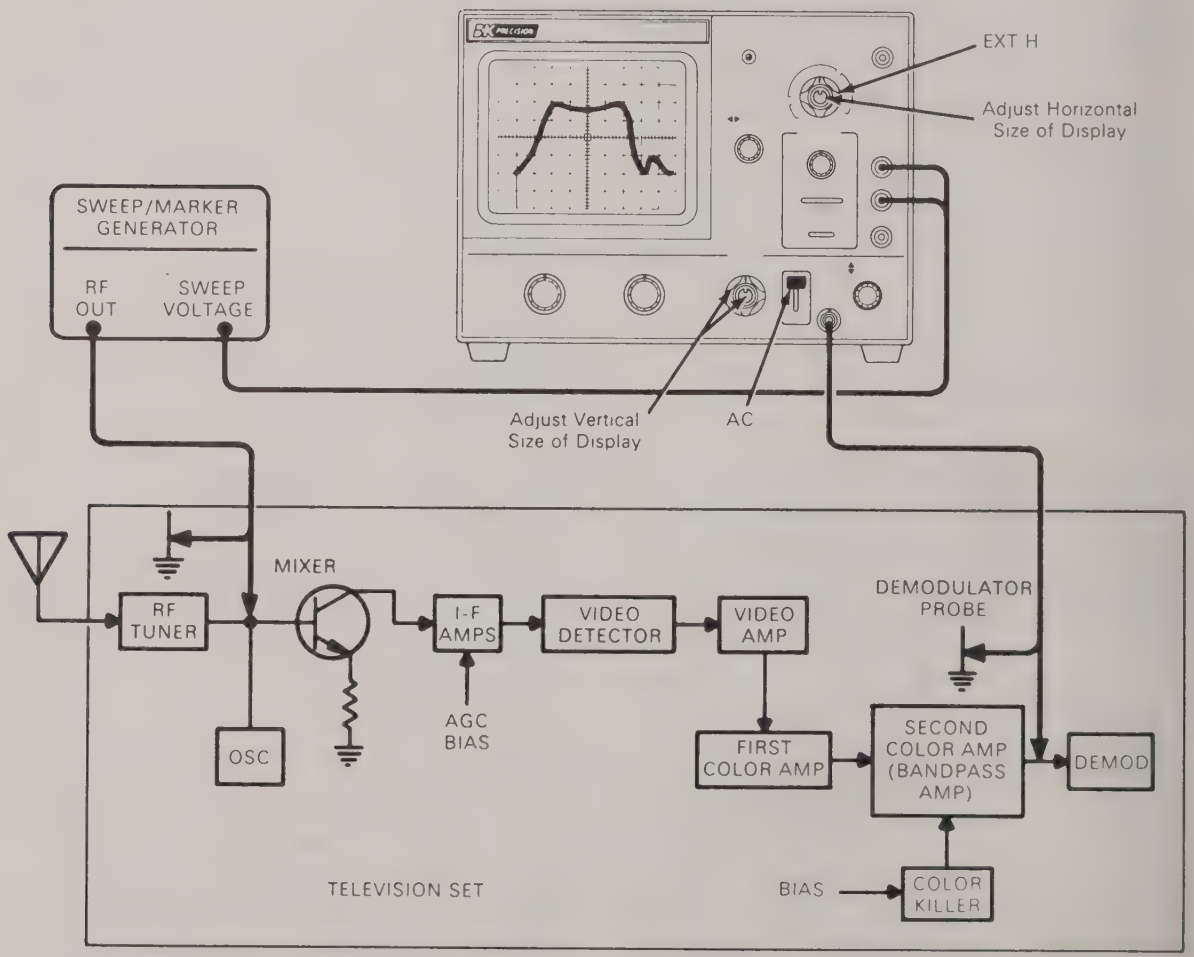


Fig. 21. Typical chroma alignment set-up.

drastically. Follow the manufacturer's procedure explicitly for such direct injection of video sweep for chroma alignment.

1. Leave the sweep/marker generator and AGC bias connected as for IF alignment. Set the sweep generator to sweep approximately the 41 to 44 MHz band of frequencies. Use the same IF injection level that was used for IF alignment.

2. Apply the proper DC bias to the color killer to enable the color amplifiers (bandpass amplifiers). Refer to the manufacturer's instructions for the correct bias level.

3. Synchronize the oscilloscope sweep as previously described for tuner alignment.

4. Use a demodulator probe for the vertical input to the oscilloscope. Measure the response curve at the input to the demodulators.

5. Set the vertical gain controls of the oscilloscope (VOLTS/CM and VARIABLE) for a convenient viewing size on the screen.

6. A response curve similar to that shown in Fig. 22 should be seen. Select the marker generator frequencies of interest. Refer to the manufacturer's instructions for bandpass specifications and alignment procedures.

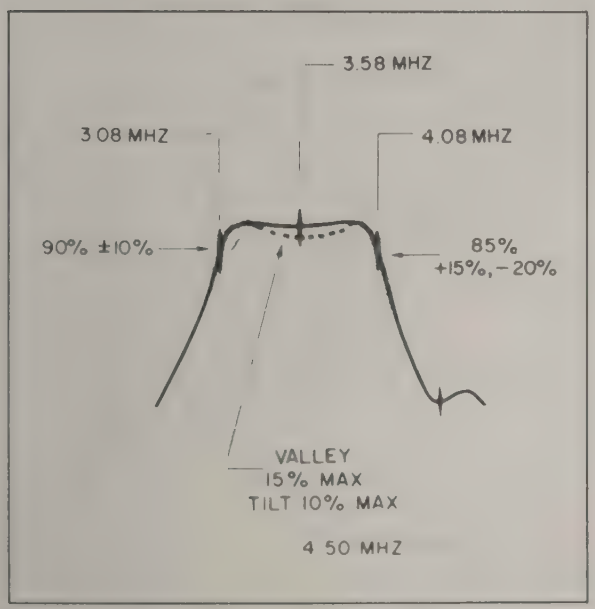


Fig. 22. Typical chroma response curve, showing tolerance ranges of response levels.

NOTES

FM RECEIVER ALIGNMENT

(Refer to Fig. 23)

1. Connect a sweep generator to the mixer input of the FM receiver. Set the sweep generator for a 10.7 MHz centered sweep.

2. Connect the sweep voltage output of the sweep generator to the external horizontal input jack of the oscilloscope and set the oscilloscope controls for external horizontal sweep.

3. Connect the vertical input probe to the demodulator input of the FM receiver.

4. Adjust oscilloscope vertical and horizontal gain controls for a display similar to that shown in Fig. 23A. The narrow bandpass is easier to interpret if 5X magnification is used.

5. Set the marker generator precisely to 10.7 MHz. The marker "pip" should be in the center of the bandpass.

6. Align the IF amplifiers according to the manufacturer's specifications.

7. Move the probe to the demodulator output. The "S" curve should be displayed, and the 10.7 MHz "pip" should appear exactly in the center. (See Fig. 23B.) Adjust the demodulator according to the manufacturer's instructions so the marker moves equal distances from center as the marker frequency is increased and decreased equal amounts from the 10.7 MHz center frequency.

FREQUENCY MEASUREMENT

1. Connect the sine wave of known frequency to the EXT SYNC/HOR jack of the oscilloscope and set the SWEEP TIME/CM control to EXT. This provides external horizontal input.

2. Connect the vertical input probe to the unknown frequency.

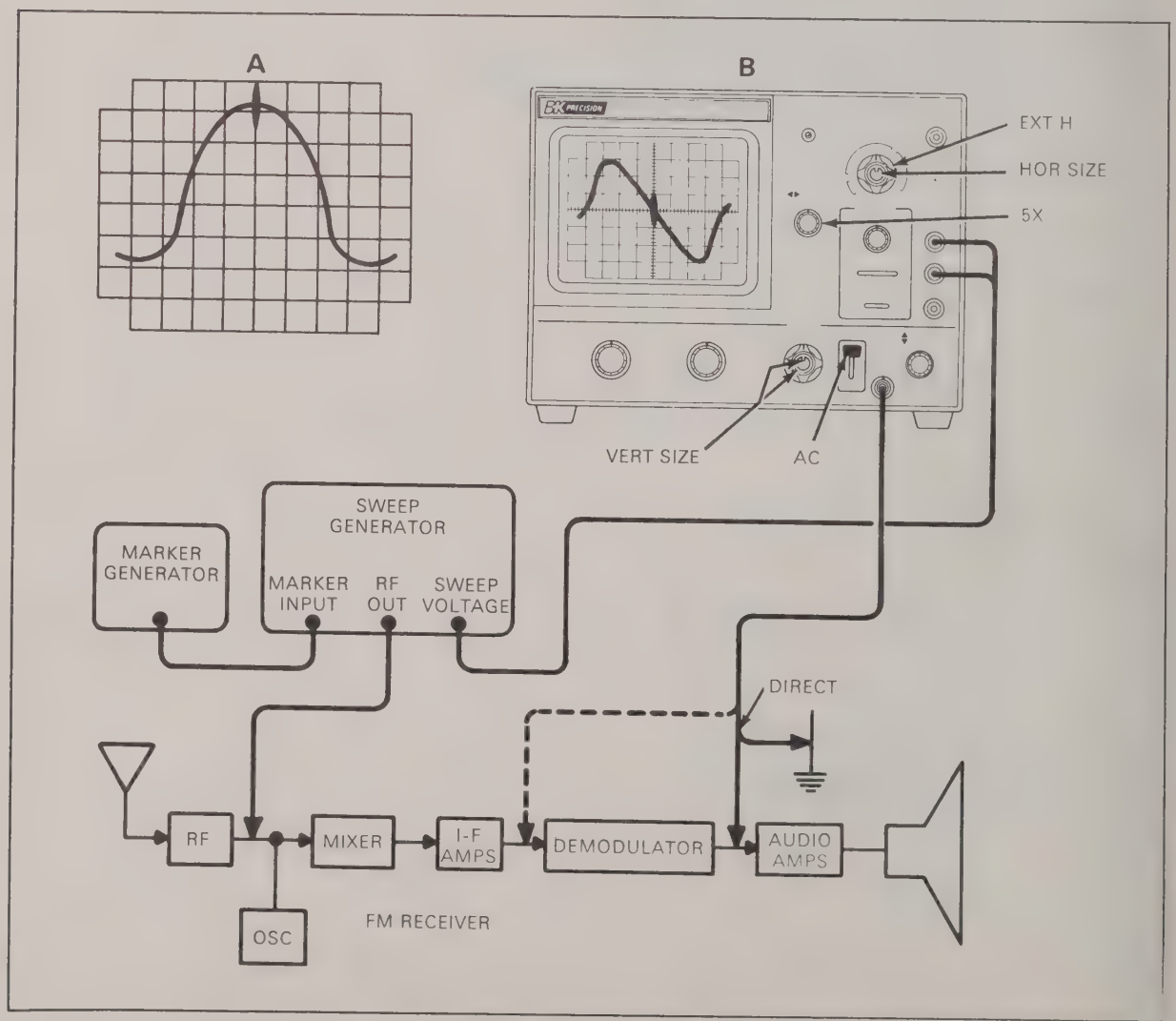


Fig. 23. Typical FM receiver alignment set-up.

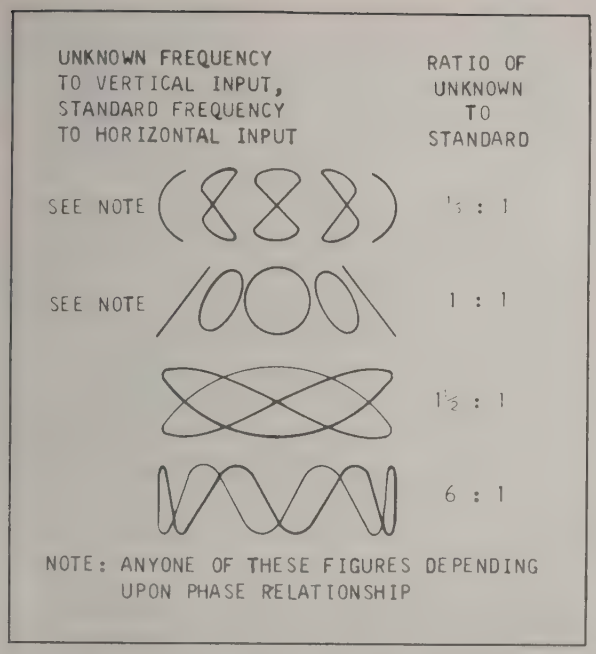


Fig. 24. Lessajous waveforms used for frequency measurement.

3. Adjust the vertical and horizontal size controls for a convenient, easy-to-read size of display.

4. The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies. See Fig. 24.

PHASE MEASUREMENT

Phase measurements may be made with an oscilloscope. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers or other audio networks. Distortion due to non-linear amplification is also displayed in the oscilloscope waveform.

A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

To make phase measurements, use the following procedure (refer to Fig. 25):

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.

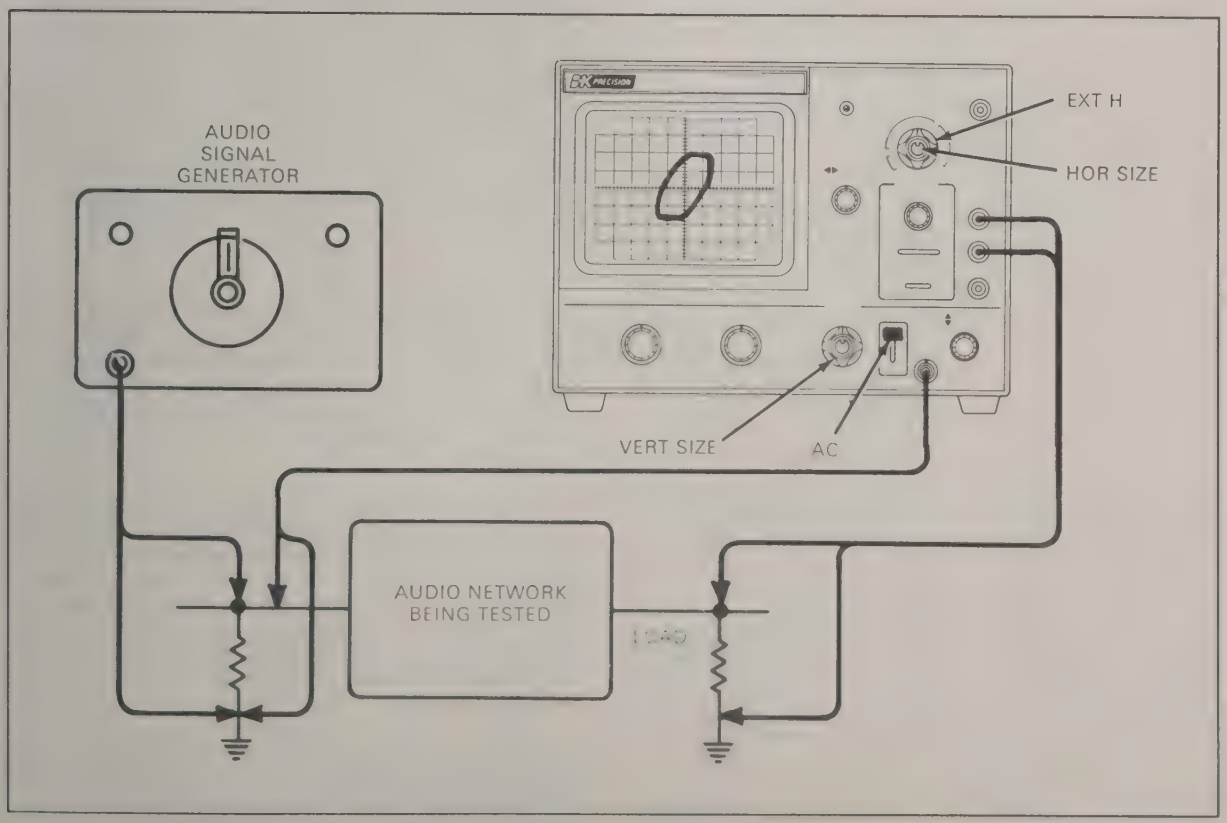


Fig. 25. Typical phase measurement.

2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.

3. Connect an external horizontal input cable from the output of the test circuit to the EXT SYNC/HOR jack of the oscilloscope.

4. Set the SWEEP TIME/CM control to EXT for external horizontal sweep.

5. Connect the V INPUT probe to the input of the test circuit. (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reversed. Use the higher vertical gain of the oscilloscope for the lower level signal.)

6. Adjust the vertical and horizontal gain controls for a suitable viewing size.

7. Some typical results are shown in Fig. 26. If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle.

   A 90° phase shift produces a circular oscilloscope pattern.

Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 27.

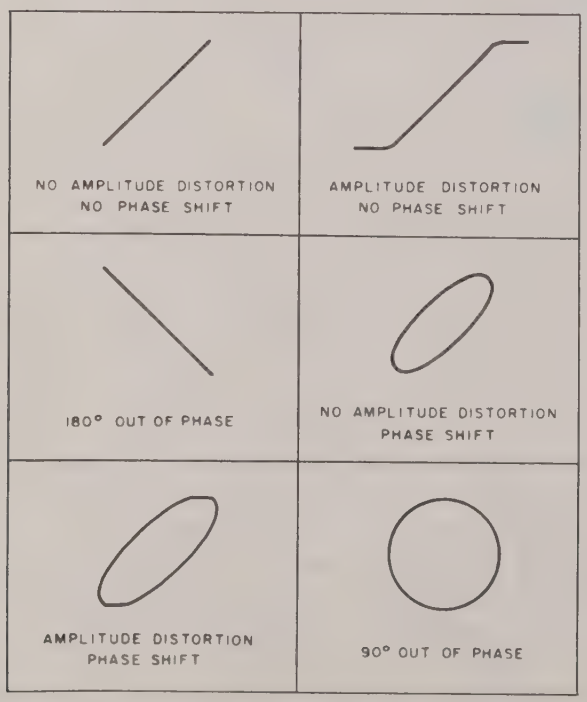


Fig. 26. Typical phase measurement oscilloscope display.

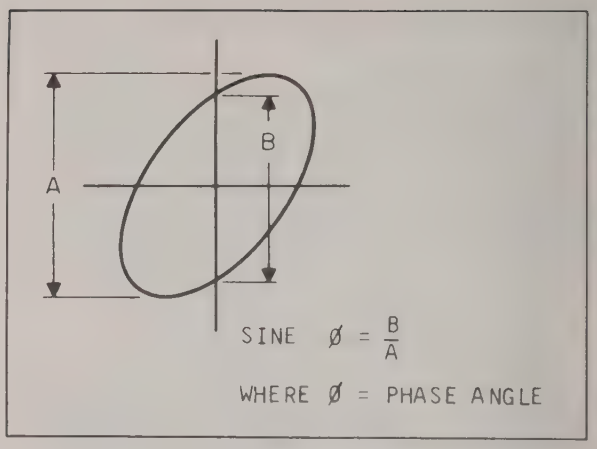


Fig. 27. Phase shift calculation.

SQUARE WAVE TESTING OF AMPLIFIERS

INTRODUCTION

A square wave generator and a low distortion oscilloscope, such as this instrument, can be used to display various types of distortion present in electronic circuits. A square wave of a given frequency contains a large number of odd harmonics of that frequency. If a 500 Hz square wave is injected into a circuit, frequency components of 1.5 kHz, 2.5 kHz, 3.5 kHz, are also provided. Since vacuum tubes and transistors are non-linear, it is difficult to amplify and reproduce a square wave which is identical to the input signal. Interelectrode capacitances, junction capacitances, stray capacitances as well as limited device and transformer response are a few of the factors which prevent faithful reproduction of a square wave signal. A well-designed amplifier can minimize the distortion caused by these limitations. Poorly designed or defective amplifiers can introduce considerable distortion to the point where their performance is unsatisfactory.

As stated before, a square wave contains a large number of odd harmonics. By injecting a 500 Hz sine wave into an amplifier we can evaluate amplifier response at 500 Hz only, but by injecting a square wave of the same frequency we can determine how the amplifier would respond to input signals from 500 Hz up to the 15th or 21st harmonic.

The need for square wave evaluation becomes apparent if we realize that some audio amplifiers will be required during normal use to pass simultaneously a large number of different frequencies. With a square wave we have a controlled signal with which we can evaluate the input and output quality of a signal of many frequencies (the harmonics of the square wave) which is what the amplifier sees when amplifying complex waveforms of musical instruments or voices.

The square wave output of the signal generator must be extremely flat so that it does not contribute to any distortion that may be observed when evaluating amplifier response. The oscilloscope vertical input should be set to

DC as it will introduce the least distortion, especially at low frequencies. When checking amplifier response, the frequency of the square wave input should be varied from the low end of the amplifier bandpass up toward the upper end of the bandpass; however, because of the harmonic content of the square wave, distortion will occur before the upper end of the amplifier bandpass is reached.

It should be noted that the actual response check of an amplifier should be made using a sine wave signal. This is especially important in limited bandwidth amplifiers (voice amplifiers). The square wave signal provides a quick check of amplifier performance and will give an estimate of overall amplifier quality. The square wave will also reveal some deficiencies not readily apparent when using a sine wave signal. Whether a sine wave or square wave is used for testing the amplifier, it is important that the manufacturer's specifications on the amplifier be known in order to make a better judgment of its performance.

TESTING PROCEDURE (Refer to Fig. 28)

1. Connect the output of the square wave generator to the input of the amplifier being tested.

2. Connect the vertical test probe of the oscilloscope to the output of the amplifier being tested.

3. If the DC component of the circuit being tested is sufficiently low to allow both AC and DC component to be viewed, use the DC position of the AC-GND-DC switch. However, the AC position may be used without affecting the results except at very low frequencies (below 5 Hz).

4. Adjust the vertical gain controls for a convenient viewing height.

5. Using INT sync and AUTO triggering, adjust the sweep time controls for one cycle of square wave output on the screen.

6. For a close-up view of a portion of the square wave, use the 5X magnification.

ANALYZING THE WAVEFORMS

The short rise time which occurs at the beginning of the half-cycle is created by the in-phase sum of all the medium and high-frequency sine wave components. The same holds true for the rapid drop at the end of the half-cycle from maximum amplitude to zero amplitude at the 180° or half-cycle point. Therefore, a theoretical reduction in amplitude alone of the high-frequency components should produce a rounding of the square corners at all four points of one square wave cycle (see Fig. 29).

Distortion can be classified into three distinct categories:

1. The first is frequency distortion and refers to the change from normal amplitude of a component of a complex waveform. In other words, the introduction in an

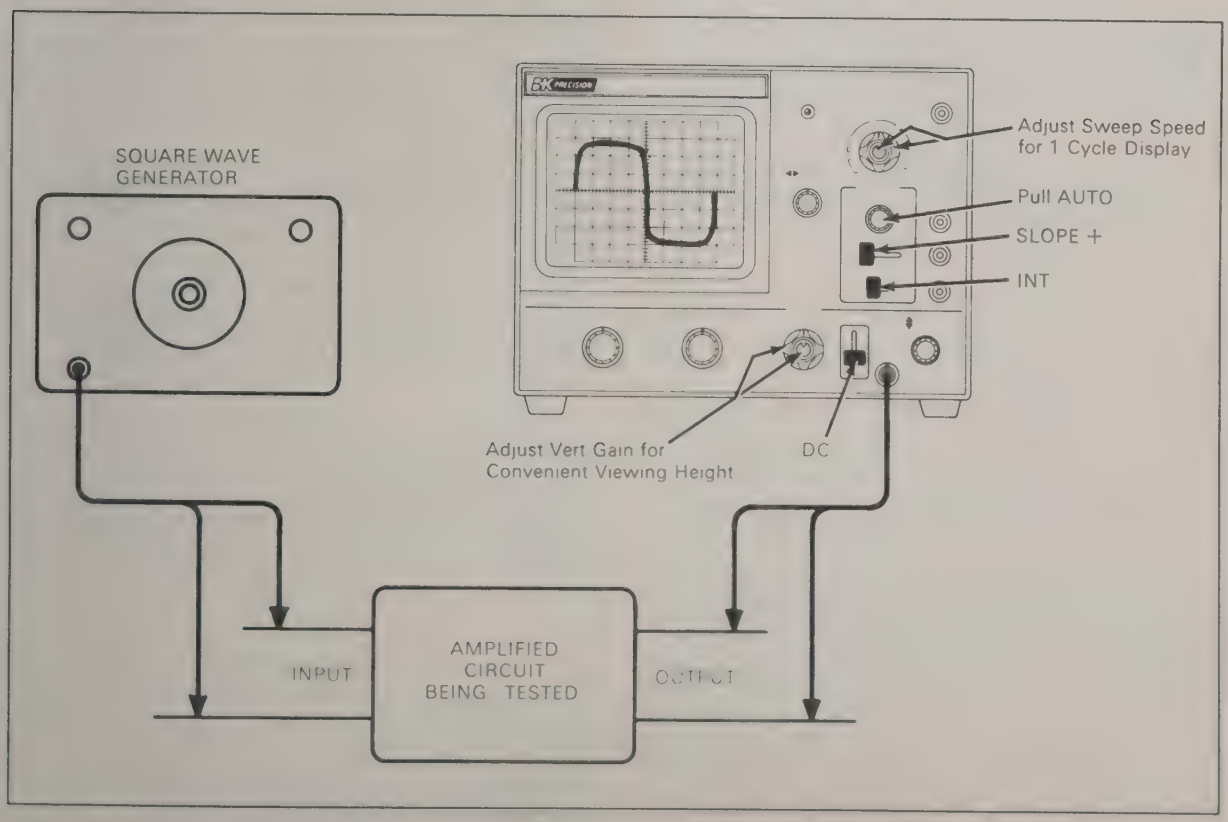


Fig. 28. Equipment set-up for square-wave testing of amplifiers.

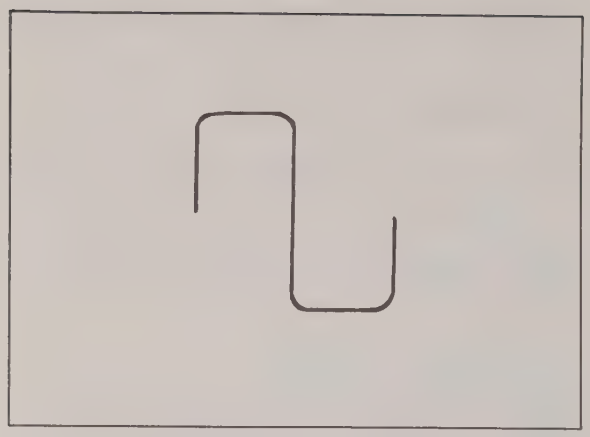


Fig. 29. Square-wave response with high-frequency loss.

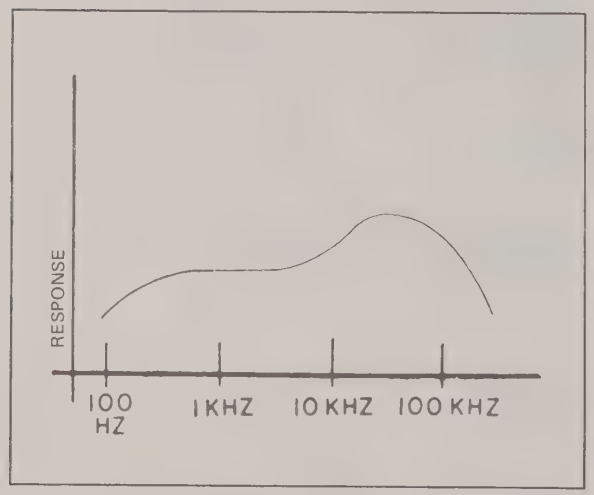


Fig. 30. Response curve of amplifier with poor low and high ends.

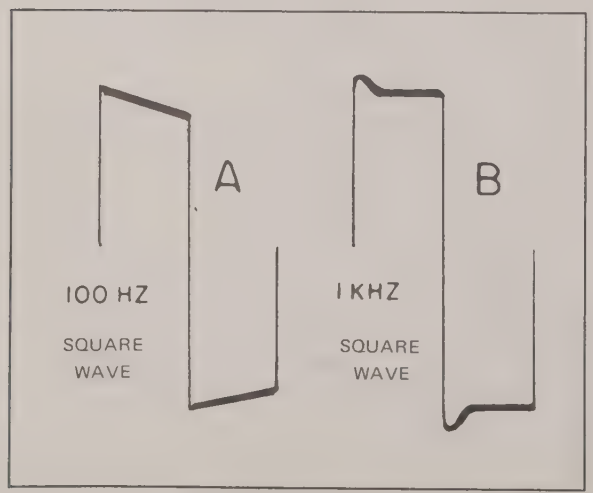


Fig. 31. Resultant 100 Hz and 1 kHz square-waves from amplifier in Fig. 30.

amplifier circuit of resonant networks or selective filters created by combination of reactive components will create peaks or dips in an otherwise flat frequency response curve.

2. The second is non-linear distortion and refers to a change in waveshape produced by application of the waveshape to non-linear components or elements such as vacuum tubes, an iron core transformer, and in an extreme case a deliberate non-linear circuit such as a clipper network.

3. The third is delay or phase distortion, which is distortion produced by a shift in phase between one or more components of a complex waveform.

In actual practice, a reduction in amplitude of a square wave component (sinusoidal harmonic) is usually caused by a frequency selective network which includes capacity, inductance or both. The presence of the C or L introduces a difference in phase angle between components, creating phase distortion or delay distortion. Therefore, in square wave testing of practical circuitry, we will usually find that the distorted square wave includes a combination of amplitude and phase distortion clues.

In a typical wide band amplifier, a square wave check accurately reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in Fig. 30, revealing poor, low-frequency boost. A 100 Hz square wave applied to the input of this amplifier will appear as in Fig. 31A. This figure indicates satisfactory medium-frequency response (approximately 1 kHz to 2 kHz) but shows poor, low-frequency response. Next, a 1000 Hz square wave applied to the input of this same amplifier will appear as in Fig. 31B. This figure displays good frequency response in the region of 1000 to 4000 Hz but clearly reveals the overcompensation at the higher 10 kHz region by the sharp rise at the top of the leading edge of the square wave.

As a rule of thumb, it can be said that a square wave can be used to reveal response and phase relationships up to the 15th or 20th odd harmonic or up to approximately 40 times the fundamental of the square wave. Using this rule of thumb, it is seen that wide band circuitry will require at least a two-frequency check to properly analyze the complete spectrum. In the case illustrated by Fig. 30, a 100 Hz square wave will encompass components up to about 4000 Hz. To analyze above 4000 Hz and beyond 10,000 Hz, a 1000 Hz square wave should be satisfactory.

Now, the region between 100 Hz and 4000 Hz in Fig. 30 shows a rise from poor, low-frequency response to a flattening out from between 1000 and 4000 Hz. Therefore, we can expect that the higher frequency components in the 100 Hz square wave will be relatively normal in amplitude and phase but that the lower frequency components in this same square wave will be strongly modified by the poor low-frequency response of this amplifier. See Fig. 31A.

If the combination of elements in this amplifier were such as to only depress the low-frequency components in the square wave, a curve similar to Fig. 32 would be obtained. However, reduction in amplitude to a component, as already noted, is usually caused by a reactive element, causing, in turn, a phase shift of the component, producing the strong tilt of Fig. 31A. Fig. 33 reveals a graphical development of a similarly tilted square wave. The

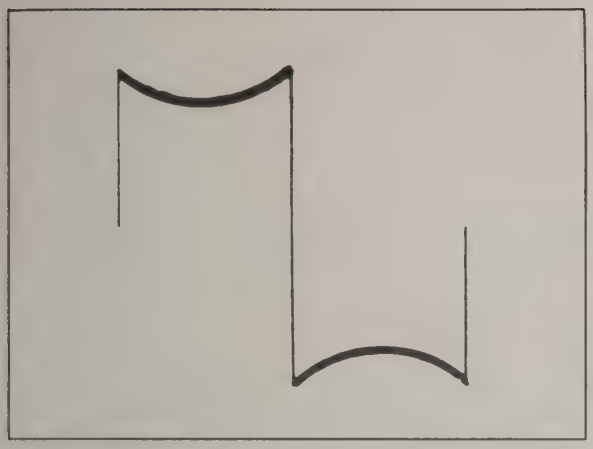


Fig. 32. Reduction of square-wave fundamental frequency component in a tuned circuit.

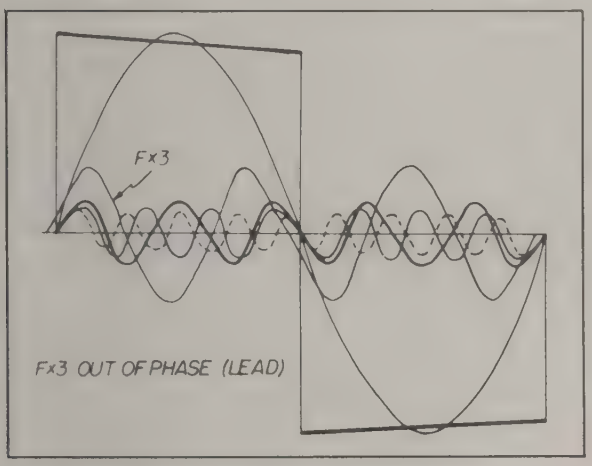


Fig. 33. Square-wave tilt resulting from 3rd harmonic phase shift.

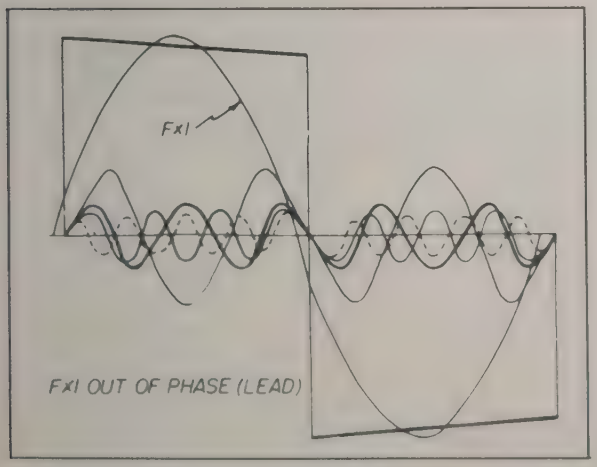


Fig. 34. Tilt resulting from phase shift of fundamental frequency in a leading direction.

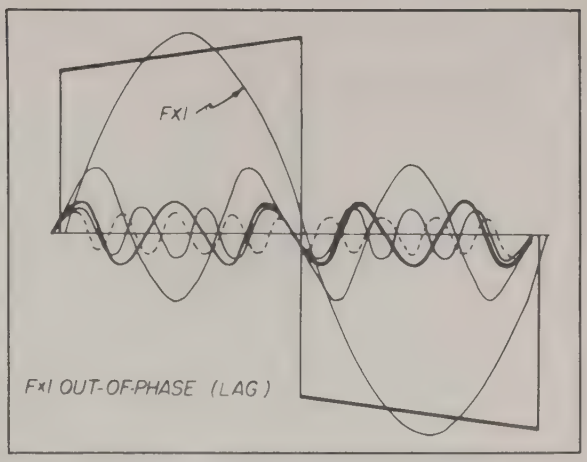


Fig. 35. Tilt resulting from phase shift of fundamental frequency in a lagging direction.

tilt is seen to be caused by the strong influence of the phase-shifted 3rd harmonic. It also becomes evident that very slight shifts in phase are quickly shown up by tilt in the square wave.

Fig. 34 indicates the tilt in square wave shape produced by a 10° phase shift of a low-frequency element in a leading direction. Fig. 35 indicates a 10° phase shift in a low-frequency component in a lagging direction. The tilts are opposite in the two cases because of the difference in polarity of the phase angle in the two cases as can be checked through algebraic addition of components.

Fig. 36 indicates low-frequency components which have been reduced in amplitude and shifted in phase. It will be noted that these examples of low-frequency distortion are characterized by change in shape of the flat top portion of the square wave.

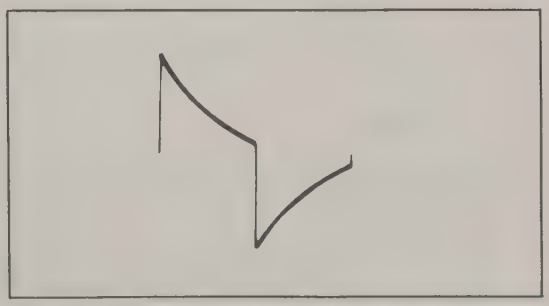


Fig. 36. Low-frequency component loss and phase shift.

Fig. 31B, previously discussed, revealed high-frequency overshoot produced by rising amplifier response at the higher frequencies. It should again be noted that this overshoot makes itself evident at the top of the leading edge of the square wave. This characteristic relationship is explained by remembering that in a normal well-shaped square wave, the sharp rise of the leading edge is created by the summation of a practically infinite number of harmonic components. If an abnormal rise in amplifier response occurs at high frequencies, the high-frequency components

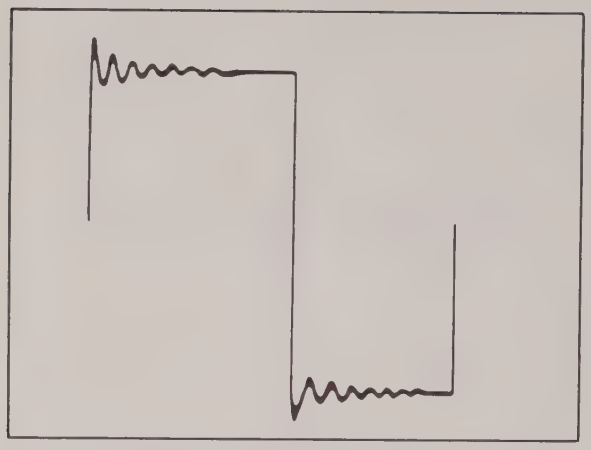


Fig. 37. Effect of high-frequency boost and poor damping.

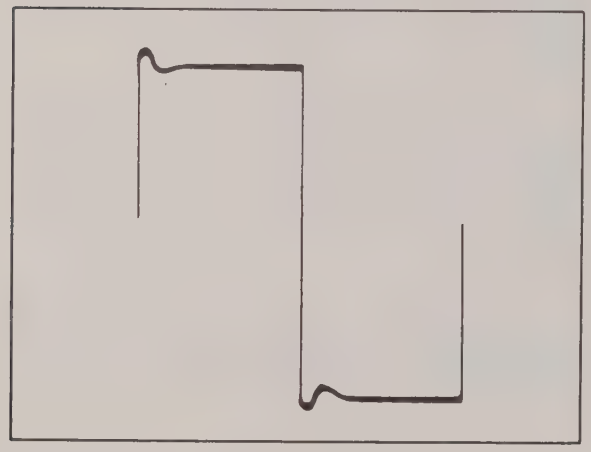


Fig. 38. Effect of high-frequency boost and good damping.

in the square wave will be amplified disporportionately greater than other components creating a high algebraic sum along the leading edge.

Fig. 37 indicates high-frequency boost in an amplifier accompanied by a lightly damped "shock" transient. The sinusoidal type of dimishing oscillation along the top of the square wave indicates a transient oscillation in a relatively high "Q" network in the amplifier circuit. In this case, the sudden transition in the square wave potential from a sharply rising relatively high-frequency voltage to a level value of low-frequency voltage supplies the energy for oscillation in the resonant network. If this network in the amplifier is reasonably heavily damped, then a single cycle transient oscillation may be produced as indicated in Fig. 38.

Fig. 39 summarizes the preceding explanation and figures as a handy reference.

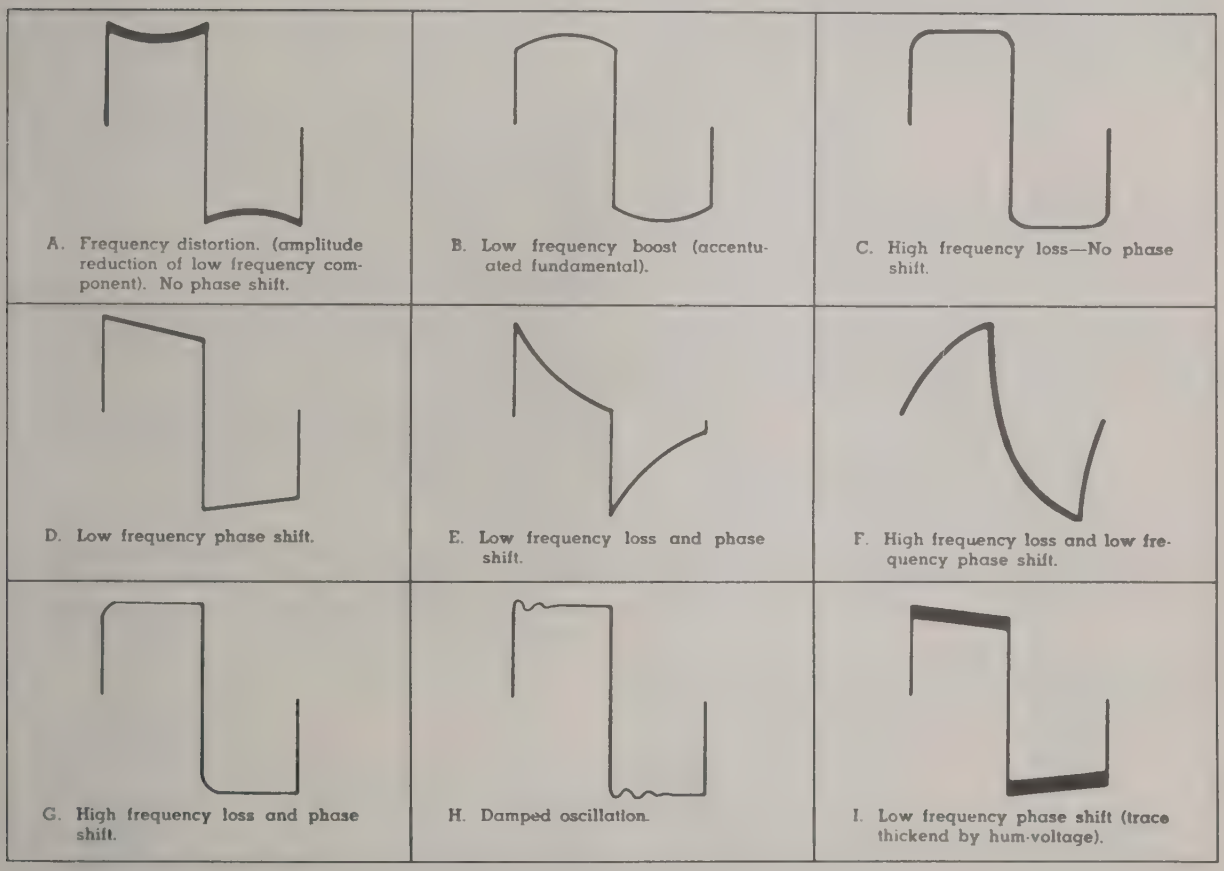

A. Frequency distortion. (amplitude reduction of low frequency component). No phase shift.
B. Low frequency boost (accentuated fundamental).
C. High frequency loss—No phase shift.
D. Low frequency phase shift.
E. Low frequency loss and phase shift.
F. High frequency loss and low frequency phase shift.
G. High frequency loss and phase shift.
H. Damped oscillation.
I. Low frequency phase shift (trace thickend by hum-voltage).

Fig. 39. Summary of waveform analysis for square-wave testing of amplifiers.

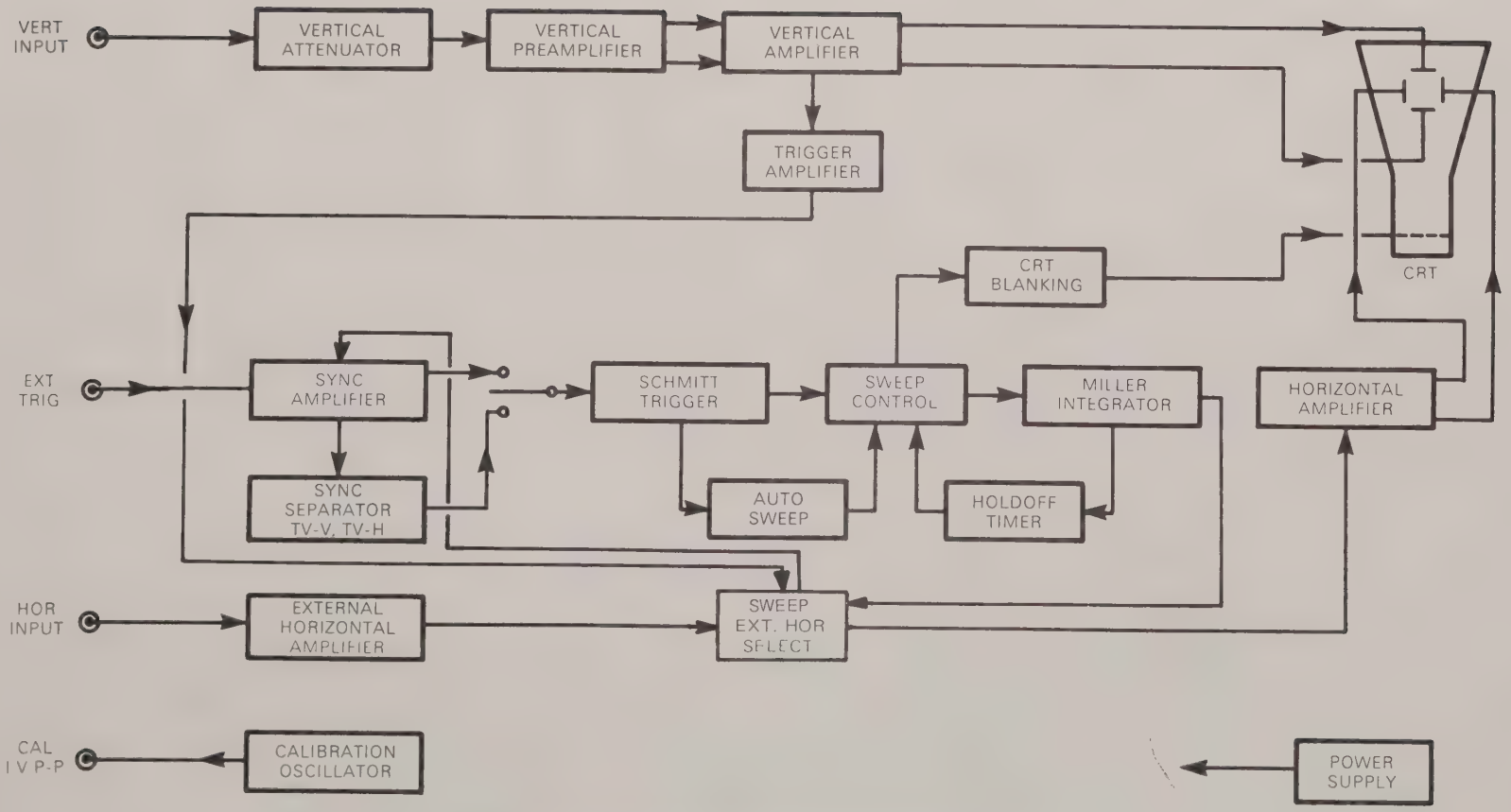


Fig. 40. Block diagram of Model 1461 oscilloscope.

1461 CIRCUIT DESCRIPTION

The block diagram of Fig. 40 outlines the circuit breakdown of the oscilloscope. Circuit details are obtained by reference to the schematic diagram.

VERTICAL AMPLIFIER

The signal to be displayed is applied to the VERT INPUT jack j1 and passes through the input attenuator section. Attenuation values of X1, X10, X100 and X1000 are selected by VOLTS/CM switch S104.

The input signal is then applied to the vertical preamplifier stage. Q121, a dual FET, forms a balanced differential amplifier input stage with output signals of opposite polarity. VR111 is the side panel DC BALANCE control. Emitter followers Q123 and Q124 drive differential amplifier Q125 and Q126. Stage gain is changed at the emitters of Q125 and Q126 by S104 to provide fixed gains of 5, 2, and 1. Variable control VR115 adjusts the signal level to the inputs of Q403 and Q404 while VERTICAL POSITION, VR112, and amplifier calibration VR113 are accomplished at the emitters of Q143 and Q144.

The vertical amplifier stage consists of transistors Q109 through Q120, which amplifies the signal to the levels required to drive the vertical deflection plates of the CRT. VR105 is the trace centering adjustment, while VR104 and TC113 are high-frequency compensation adjustments.

Transistors Q127 and Q128 form the TRIGGER AMPLIFIER which provides a sample of the vertical signal to the sync amplifier for internal triggering.

SYNC AMPLIFIER AND INVERTER

Source switch S303 selects either INTERNAL (from preamplifiers) or EXTERNAL triggering. The trigger signal is then fed to differential amplifier IC305. Either the inverted (SLOPE-) or non-inverted (SLOPE+) signal is selected by SYNC switch S304. LEVEL control VR310 adds a DC component to the output of IC305.

SYNC SEPARATOR

When TV+ or TV- is selected, the output of IC305 is routed to the SYNC SEPARATOR circuit consisting of Q320 and Q319. Q320 is held at cutoff by a negative voltage developed across C332 corresponding to an average value of the input signal. Positive-going pulses drive Q320 out of cutoff. The output of Q320 corresponds to the sync tips of the composite video signal.

When in the TVV positions of the SWEEP TIME/CM switch (.1mS to .5 SEC), Q319 is on; this allows C331 to filter out the horizontal sync pulses, permitting only vertical sync pulses to pass to the sweep circuit. In the TV-H positions (50μSEC to 1μSEC), Q319 is turned off, removing C331 and allowing horizontal sync pulses to the sweep circuit.

SWEEP CIRCUIT

The trigger signal passes through emitter follower Q303, and to the SCHMITT TRIGGER circuit consisting of two gates of IC303. The output pulses from IC303 clock the SWEEP CONTROL flip-flop IC301. On the negative edge of the clock waveform, the Q output of IC301 goes low, turning off Q307 to initiate the sweep.

Transistors Q308 and Q309 and the timing capacitors and resistors selected by the SWEEP TIME/CM switch, form a MILLER INTEGRATING circuit to provide a linear ramp voltage. The sweep ramp from the collector of Q309 is fed to PIN 6 of HOLDOFF TIMER IC302. The output of IC302 holds Q307 on through IC301 to prevent the sweep from starting until the retrace is complete. The holdoff time is determined by capacitors C309, C310, and C311.

As soon as the Q output of IC301 goes low, the reset of IC301 is held low by IC303 to exclude any new clock pulses until the sweep ramp is terminated. When the sweep ramp exceeds the level set by VR309 (SWEEP LENGTH), IC302 places a low on the set input of IC301. A low on the set input forces the Q output of IC301 high which turns on Q307, terminating the sweep.

AUTO SWEEP

Transistors Q304, Q305, and Q306 form the AUTO SWEEP circuit. When the trigger level control is pulled out (AUTO) and no signal is present at the trigger amplifier, C303 charges and turns Q306 on; this places a low on the reset of IC301 and allows a sweep to recirculate at a rate determined by the resistor and capacitor selected by the SWEEP TIME/CM switch. When a trigger signal is present, transistors Q304 and Q305 discharge C303, turning Q306 off and enabling the sweep to trigger on the incoming signal.

HORIZONTAL AMPLIFIER

The sweep ramp from the collector of Q309 is applied through VR306 (TIMING ADJ.) to the input of the horizontal amplifier consisting of Q314, Q315, Q317, and Q318. VR305 is a horizontal contering adjustment and VR307 is the horizontal position control.

The output of transistors Q317 and Q318 is applied to the horizontal deflection plates of the CRT. VR303 is the X5 magnification adjustment and VR304 is the magnification centering adjustment.

1 VOLT CAL SIGNAL

Transistors Q301 and Q302 provide a 60 Hz square wave. VR212 adjusts the amplitude of the CAL SIGNAL.

POWER SUPPLY

The power supply provides all voltages necessary for operating the oscilloscope.

Regulated output voltages of +10, -8, and +5 are provided for all logic and amplifier circuits. Amplifier output stages require the 180V.

The accelerating voltage for the CRT is derived from a DC-to-DC converter consisting of Q142 and T101. The output of T101 is rectified and filtered and applied through voltage dividers to the CRT. A portion of the high voltage is fed to a regulator circuit consisting of Q129 and Q130 to provide a constant accelerating potential under varied operating conditions.

CALIBRATION AND MAINTENANCE

The calibration adjustments outlined here are those which can be performed with a minimum of specialized test equipment. Additional internal adjustments of frequency compensation and horizontal sweep linearity should not be attempted without complete service information and specialized test equipment. Requests for complete service information for this oscilloscope should be addressed to:

SERVICE DEPARTMENT

B & K-PRECISION TEST EQUIPMENT PRODUCT GROUP
DYNASCAN CORPORATION
6460 W. Cortland Street
Chicago, Illinois 60635

Internal adjustments outlined in the calibration procedure can be located by reference to Figs. 41 and 42.

HOUSING REMOVAL

1. Remove 6 screws, 2 on left side, 2 on right side, and 2 on top.
2. Lift cover off scope.

230 VAC OPERATION

1. Remove housing from scope.
2. Remove plug from P101
3. Rotate plug 180° and reinsert on P101.
4. Replace 0.7A fuse with 0.3A fuse.
5. Replace housing.

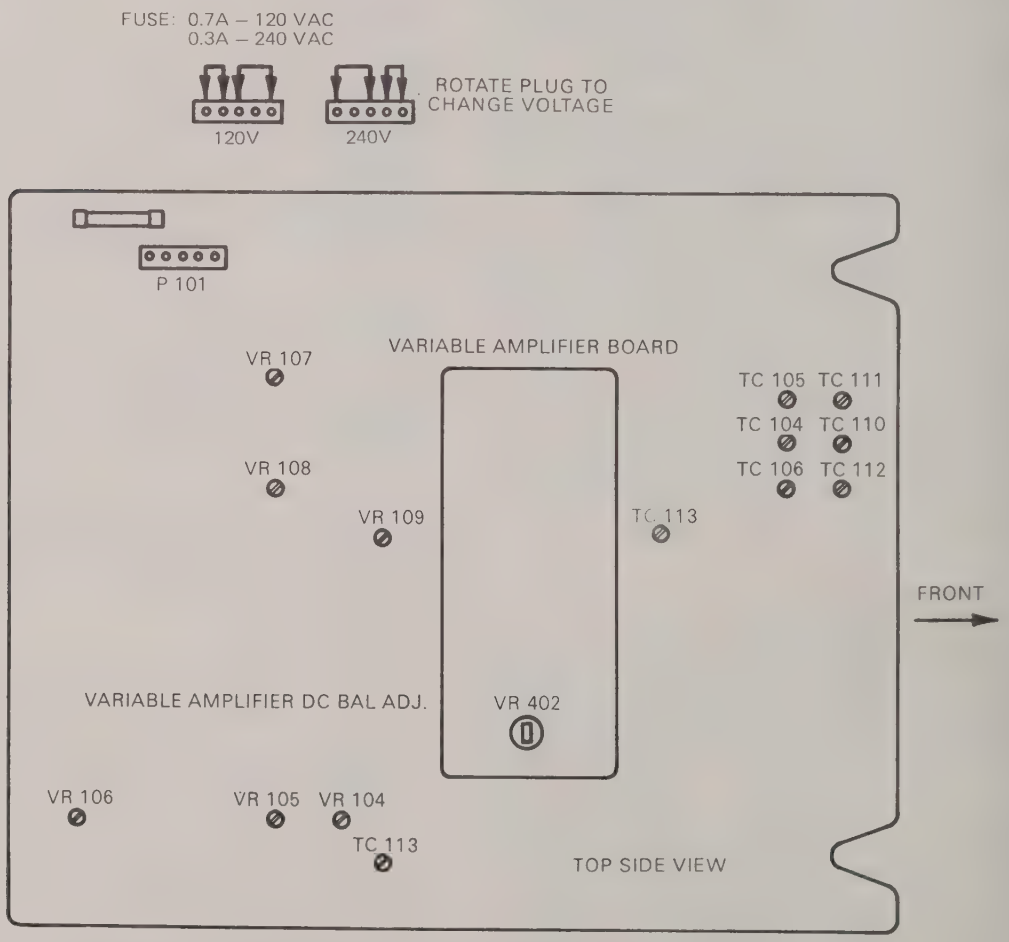


Fig. 41. Calibration location – vertical amplifier and power supply board.

VR 104—HIGH FREQUENCY RESPONSE ADJ.
VR 105—DISPLAY CENTER ADJ.
VR 106—ASTIG.
VR 107—1.9 KV ADJ.
VR 108—INTENSITY ADJ.
VR 109—180 V ADJ.
VR 113 – VERTICAL ADJ.
VR 402 – VARIABLE AMPLIFIER DC BAL ADJ.

TC 104—1/10 RANGE SQUARE WAVE ADJ
TC 105—1/100 RANGE SQUARE WAVE ADJ
TC 106—1/1000 RANGE SQUARE WAVE ADJ
TC 110—1/10 RANGE INPUT CAPACITY ADJ
TC 111—1/100 RANGE INPUT CAPACITY ADJ
TC 112—1/1000 RANGE INPUT CAPACITY ADJ
TC 113—MEDIUM FREQUENCY RESPONSE ADJ.

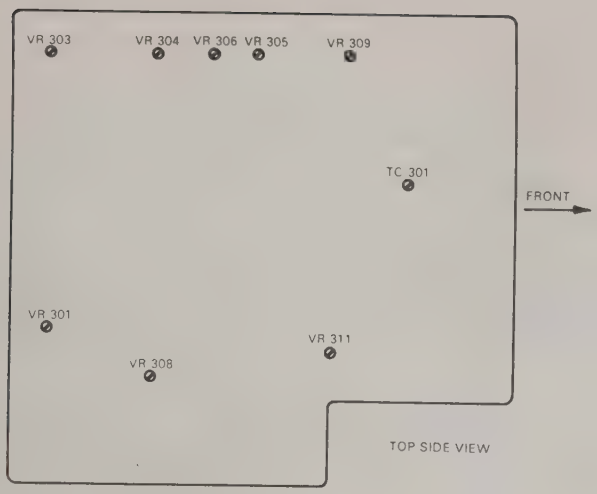


Fig. 42. Calibration location – horizontal amplifier board.

VR 301—CAL VOLTAGE ADJ.
VR 303—MAG ADJ.
VR 304—MAG CENTER ADJ.
VR 305—HORIZONTAL POSITION ADJ.
VR 306—TIMING ADJ.
VR 308—EXT. HORIZONTAL POSITION ADJ
VR 309—SWEEP LENGTH
VR 311—TRIGGER CENTER ADJ.
TC 301—HIGH SPEED SWEEP (1μ S—50μ S) TIMING ADJ.

GRATICULE REMOVAL

1. Grasp bezel with both hands at top and bottom. Pull bezel uniformly forward to unlock mounting legs from front panel. Caution should be used to keep bezel parallel to front panel when removing, to avoid breakage of mounting legs.
2. Lift off graticule from bezel.
3. Reinsert graticule on bezel and snap bezel into front panel mounting holes.

CRT ROTATION ADJUSTMENT

1. Loosen two screws on rear panel with adjustment slots.
2. Grasp cover and align horizontal trace with horizontal graticule line.
3. Tighten two screws.

DC BALANCE ADJUSTMENT

1. Adjust controls to obtain a horizontal trace.
2. Adjust ▲▼ POSITION control to center the trace vertically on the CRT.
3. Rotate the V ATTEN. SWITCH from 1V/CM to 2V/CM to 5V/CM while observing the trace.
4. If the trace moves vertically more than 5 mm while performing STEP 3, adjust the DC BAL (side panel screwdriver adjustment) so that the vertical movement of the trace does not exceed 5 mm while performing STEP 3.

VERTICAL GAIN ADJUSTMENT

The following adjustments should be attempted only if a square wave generator with 1% or better amplitude accuracy is available.

Procedure:

1. Set VOLTS/CM switch to .01V/CM.
2. Apply 1 kHz square wave of 50 mV peak-to-peak into CH A input connector. Set mode switch to CH A.
3. Adjust VR113 for exactly 5 CM of deflection on CRT.

HORIZONTAL POSITION ADJUSTMENT

1. Set ◄► POSITION control to the mechanical center of rotation.
2. Set SWEEP TIME/CM switch to 1mS/CM
3. Adjust VR305 so that the line on the scope is horizontally centered on CRT.
4. Turn the ◄► POSITION control full CW and CCW. The amount of deflection in both directions should be a minimum of 4 CM.

ASTIGMATISM ADJUSTMENT

1. Rotate SWEEP TIME/CM switch to EXT H. position.
2. Adjust FOCUS control and VR106 (ASTIG.) for a small, bright spot with INTENSITY set at midrange.

WARRANTY SERVICE INSTRUCTIONS

1. Refer to the MAINTENANCE section of your B & K-Precision instruction manual for adjustments that may be applicable.

2. Defective parts removed from units which are within the One Year Limited Warranty period should be sent PREPAID to the Service Department listed below. Be sure to state the model and serial number of the unit from which the parts were removed and date the unit was purchased. These parts will be exchanged at no charge, under the terms of the Warranty.

3. If the above-mentioned procedures do not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred) to the nearest B & K-Precision authorized service agency (see list enclosed with unit).

If your list of authorized B & K-Precision service agencies has been misplaced, contact your local distributor for the name of your nearest service agency, or write to:

Service Department

B & K-Precision Product Group
DYNASCAN CORPORATION
2815 West Irving Park Road
Chicago, Illinois 60618

LIMITED ONE-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its B & K-PRECISION product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized B & K-PRECISION service contractor or the factory service department, accompanied by proof of the date of purchase in the form of a sales receipt.

To obtain warranty coverage, this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, B & K-PRECISION, P. O. Box 35080, Chicago, Illinois 60635 within five (5 days) from the date of purchase.

EXCLUSIONS: THIS WARRANTY DOES NOT APPLY IN THE EVENT OF MISUSE OR ABUSE OF THE PRODUCT OR AS A RESULT OF UNAUTHORIZED ALTERATIONS OR REPAIRS. IT IS VOID IF THE SERIAL NUMBER IS ALTERED, DEFACED OR REMOVED.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to B & K-PRECISION Service Department, 2815 West Irving Park Road, Chicago, Illinois 60618, properly packaged to avoid damage in shipment.

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